

Vol. II
TRANSCRIPT OF RECORD
(Pages 501 to 988)

Supreme Court of the United States

OCTOBER TERM, 1944

No. 50

THE DOW CHEMICAL COMPANY, PETITIONER,

vs.

HALLIBURTON OIL WELL CEMENTING COMPANY

No. 61

HALLIBURTON OIL WELL CEMENTING COMPANY,
PETITIONER,

vs.

THE DOW CHEMICAL COMPANY

ON WRITS OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT
OF APPEALS FOR THE SIXTH CIRCUIT

PETITIONS FOR CERTIORARI FILED { APRIL 6, 1944.
APRIL 17, 1944.

CERTIORARI GRANTED MAY 15, 1944.

Supreme Court of the United States

OCTOBER TERM, 1944

No. 50

THE DOW CHEMICAL COMPANY, a Corporation,
Petitioner,

vs.

HALLIBURTON OIL WELL CEMENTING COMPANY,
a Corporation,
Respondent.

TRANSCRIPT OF RECORD

On Petition for Writ of Certiorari to the United States
Circuit Court of Appeals for the Sixth Circuit

Volume II—Pages 501 to 988

WILBER OWEN,
1601 Nicholas Building, Toledo, Ohio,
CALVIN A. CAMPBELL,
The Dow Chemical Company,
Midland, Michigan,
RUSSELL WILES,
Board of Trade Bldg., Chicago, Illinois,
DONALD L. CONNER,
The Dow Chemical Company,
Midland, Michigan,
Attorneys for Petitioner.

EARL BABCOCK,
Duncan, Oklahoma,
LEONARD S. LYON,
811 West 7th Street,
Los Angeles, California,
Attorneys for Respondent.

IN THE
UNITED STATES CIRCUIT COURT OF APPEALS
FOR THE SIXTH CIRCUIT

No.....

THE DOW CHEMICAL COMPANY, A CORPORATION,
Plaintiff-Appellant,

vs.

HALLIBURTON OIL WELL CEMENTING COMPANY,
A CORPORATION, *Defendant-Appellee.*

**Appeal from the United States District Court for the
Eastern District of Michigan, Northern Division**

CALVIN A. CAMPBELL,
The Dow Chemical Company,
Midland, Michigan,
Attorney for Plaintiff.

WILBER OWEN,
1601 Nicholas Building, Toledo, Ohio,

RUSSELL WILES,
Board of Trade Bldg., Chicago, Illinois,

DONALD L. CONNER,
The Dow Chemical Company,
Midland, Michigan,
Of Counsel for Plaintiff.

EARL BABCOCK,
Duncan, Oklahoma,
Attorney for Defendant.

LEONARD S. LYON,
811 West 7th Street,
Los Angeles, California,
Of Counsel for Defendant.

INDEX TO VOLUMES I, II AND III

	Pages
Complaint.	2, 3
Amended Answer of Defendant.....	4-12
Counterclaim.	13
Stipulation re Previous Litigation.....	13, 14
Offers of Exhibits.....	1403, 1408, 1425, 1434
Proceedings on Settlement of Findings of Fact.....	1435-1477
Findings of Fact.....	1478-1491
Conclusions of Law.....	1492
Decree.	1492-1493
Notice of Appeal.....	1494
Orders Extending Time.....	1494-1495
Stipulation Extending Time.....	1496
Statement of Points on Which Appellant Will Rely.....	1497-1500
Stipulation Approving Printed Record on Appeal.....	2048

PRIMA FACIE WITNESSES

	Direct	Cross	Redirect	Recross
				500

**PROCEEDINGS IN UNITED STATES CIRCUIT COURT
OF APPEALS—SIXTH CIRCUIT**

159

	PAGE	
Entry—Cause Argued and Submitted.....	2051	
Decree.	2051	
Opinion.	2052	
Petition for Rehearing.....	2061	
Order Denying Petition for Rehearing.....	2077	
Clerk's Certificate	2077	
Orders allowing certiorari	2078	132, 134
Miller, H. C. (Stipulation)....	235-239	
Nicholas, Carl A.....	263	283
Penhaligen, Chas.	160	163
Prutton, Carl F.....	501	614
Putnam, Sherman W.....	143	150
Rebbeck, James W.....	43	96
Shelley, Paul G.....	286	295
Steelman, Joseph E.....	301	304
Verser, Joe Kinnard.....	258	

DEFENSE WITNESSES

	Direct	Cross	Redirect	Recross
Case, L. C.....	1061	1063		
Colley, Robert H.....	1053			
Douty, Alfred	896	947		
Irish, Wm. M.....	1040	1048	1051	1052
Hathorn, Don	853	869		
Kiser, S. C.....	1075	1076		
Knappen, Russell S.....	1077	1082	1089, 1090	1090
(Stipulation)				
Knappen, Russell S.....	1090	1099	1109	1109
McKain, Bessie G.....	1054	1055		
Neubauer, John J.....	1057	1059		
Nichols, Howard M.....	1030	1034	1039	
Pitzer, Paul W.....	1002	1006	1007	
Spruance, Frank Palin.....	989	997	1001	1001
Thomas, William A.....	1010	1028		
Wescott, Blaine B.....	1110	1122		
Wright, R. L.....	1065	1069	1074	1074

REBUTTAL WITNESSES

	Direct	Cross	Redirect	Recross
Alquist, Francis N.....	1359			
Blum, Edward D. (Stipulation).....	1161			
Crampton, Fred	1290	1291		
Dougherty, Chas. I.....	1195	1213	1250	1254
Lee, Edgar	1166	1182	1194	
Lewis, James R.....	1300	1307	1314	
Luman, Edw. D. (Stipulation).....	1156			
Poffenberger, Ira N.....	1409	1413	1418	
Prupton, Carl F.....	1130	1151		
Rebbeck, James W.....	1320	1338	1357	
Sprenger, Walter	1256	1273	1289	
Staggs, Horace M.....	1158			
(Stipulation)				
Wells, Milfred	1298	1299		
Weygandt, Arthur S.....	1201			
Wolmer, Clifford E.....	1295	1297		

INDEX TO EXHIBITS

PLAINTIFF'S EXHIBITS

Exhibit Number		Pages	
		Identified	Printed
1	Grebe-Sanford patent in suit 1,877,504	15	1501
2	Grebe patent 1,916,122.....	15	1504
3	Grebe-Stoesser patent 1,998,756.....	15	1509
4	Chamberlain patent 2,024,718.....	15	1512
7	Bureau of Mines Bulletin 148.....	29	Vol. 1, 29
9	Chart of patent applications involving use of acid in wells, filed from 1866 to 1939	63	1515
9½	Revision of Exhibit 9.....	80	1516
10	Chart entitled "Streams of Knowl- edge"	65	1517
10½	Prior Art Patents and Publications..		1518-88
	Sherwood 57,982.....	65	1518
	Roberts 59,936.....	46	1521
	Dickey 106,793.....	47	1525
	Roberts 119,884.....	49	1528
	Looney 139,010.....	66	1530
	Aiken 288,150.....	86	1531
	Ball 670,577.....	70	1533
	Mitchell 825,745.....	50	1537
	Dunn 1,067,868.....	50	1541
	Muehl 1,410,827.....	71	1546
	Lake et al. 1,498,045.....	73	1549
	Tilton 1,608,869.....	74	1552
	Atkinson 1,651,311.....	53	1558
	Ranney et al. 1,806,499.....	75	1565
	Bowman 1,809,546.....	77	1570
	Young 1,858,847.....	55	1575
	British Patent 158,768.....	94	1578
	Millon article (1845)....	83	1581
	Conroy article (1901).....	87	1584
	Watts article (1912).....	89	1587
	Corbett article (1918).....	93	1588
12	Summary of Dow Shipments of acid with inhibitors February 11 to Novem- ber 10, 1932.....	113	1591-96
13	Letters, dated June 13, 1932, to Jan- uary 19, 1933, from oil industry inquir- ing about new Dow process of acid treatments for oil wells.....	148	1597-1625
14	Item in Midland paper regarding new Dow well treating process, dated June 9, 1932	148	1626

All exhibits are printed in Volume IV unless otherwise indicated.

PLAINTIFF'S EXHIBITS

Exhibit Number		Pages	
		Identified	Printed
19	First invoice of defendant for acidizing well, dated March 11, 1935.....	248	1627
20	Second invoice of defendant for acidizing well, dated May 25, 1935.....	248	1628
21	Third invoice of defendant for acidizing well, dated May 25, 1935.....	248	1628
23	Purchase order from Erle P. Halliburton, Inc., dated 5/21/34, for acid treatment of well by Dowell, Inc.....	250	1629
26	Ditto, dated October 24, 1934.....	250	1630
27	Bulk material sales receipt for 1,000 gal. Dowell X acid delivered by Dowell Inc., to Erle P. Halliburton, Inc., dated November 9, 1934.....	250	1631
31	Agreement dated March 15, 1934, for acidizing two wells by Dowell, Inc., for Steen Drilling, Inc.....	251	1632
34	Agreement dated April 20, 1934, for acidizing ten wells by Dowell, Inc., for Steen Drilling, Inc., or Erle P. Halliburton, Inc.	251	1635
38	Order from Steen Drilling, Inc., dated 3/15/34, for acid treatment by Dowell, Inc.	254	1639
40	Ditto, dated 3/17/34.....	254	1639
43	Ditto, dated 4/20/34.....	254	1640
46	Purchase order from Erle P. Halliburton, Inc., dated 5/9/34, for 2,000 gal. acid job by Dowell, Inc.....	254	1640
52	Receipt, dated 7/10/34, for well treatment performed by Dowell, Inc., for Erle P. Halliburton, Inc.....	254	1641
54	Ditto, dated 7/24/34.....	254	1642
57	Ditto, dated 8/15/34.....	254	1643
59	Ditto, dated 9/16/34.....	254	1644
60	Purchase order from Steen Drilling, Inc., dated 9/16/34, for 1,500 gal. acid job by Dowell, Inc.....	254	1645
62	Receipt, dated 10/24/34, for well treatment performed by Dowell, Inc., for Erle P. Halliburton, Inc.....	254	1646
64	Ditto, dated 11/14/34.....	254	1647
66	Ditto, dated 12/19/34.....	254	1648
67	Stipulation re testimony of R. E. Heithecker.	213	Vol. I, 213
68	Stipulation re testimony of H. C. Miller	235	Vol. I, 235

All exhibits are printed in Volume IV unless otherwise indicated.

PLAINTIFF'S EXHIBITS		
Exhibit Number		Pages Identified Printed
71	Sketches of defendant's truck tank...	262 1649
93	Article in Oil City Derrick of October 10, 1895, entitled "A Great Discovery," reporting acid treatment of well by Frasch and Van Dyke.....	1194A 1651-54
94	Table of Dowell, Inc., statistics showing growth from November 10, 1932, to 1940, inclusive. (See also Plaintiff's Exhibit 232.).....	161 1655
99	Well completion data Greendale (Michigan) oil field.....	168 Vol. I, 168
142	Carnegie Library Card cataloging available issues of Oil City Derrick...	1194A 1656
143	Item in Oil City Derrick for October 28, 1895, reporting acid treatment of wells by Frasch and Van Dyke.....	1194A 1656
144	Ditto, for November 9, 1895.....	1194A 1657
145	Ditto, for January 15, 1896.....	1194A 1658
146	Ditto, for February 20, 1896.....	1194A 1659
147	Ditto, for February 22, 1896.....	1194A 1661
148	Ditto, for March 26, 1896.....	1194A 1661
149	Ditto, for August 10, 1897.....	1194A 1663
150	Stipulation re Williams Bros. record..	13 Vol. I, 13
153	Gypsy Oil Company correspondence and reports re removal of "Gyp" scale and prevention of formation of "Gyp" in oil wells of the Glenpool, Okla., field	1087 1664-1704
154	Bartell Table showing results of corrosion tests with defendant's truck (treating) acids on strap iron test pieces	329 1705
155	Ditto, showing results on test pieces of oil well pipe from National Supply Co.	333 1706
156	Ditto, showing results on test pieces of oil well pipe from Oil Well Supply Co.	333 1707
157	Ditto, showing results on test pieces of oil well pipe from Atha Supply Co..	334 1708
158	Bartell Table showing results of corrosion tests with defendant's storage acids on strap iron test pieces.....	345 1709
159	Ditto, showing results on test pieces of oil well pipe from National Supply Co.	345 1710

PLAINTIFF'S EXHIBITS

Exhibit Number		Pages	
		Identified	Printed
160	Bartell Table showing analyses of defendant's truck (treating) acid samples	376	1711
161	Bartell Table showing analyses of acid samples taken from defendant's storage tanks	378	1712
162	Bartell Table showing analyses of acid samples taken from defendant's storage tanks and diluted to strength of defendant's truck (treating) acid samples	379	1712
163	Bartell Table showing content of copper, lead and iron in acid used by defendant in treating Zahn well, and same as to acid from defendant's storage tanks	380	1713
164	Bartell Table showing content of copper, lead and iron in acid used by defendant in treating Stella Wilcox well, and same as to acid from defendant's storage tanks	383	1714
165	Bartell Table showing content of copper, lead and iron in acid used by defendant in treating Crawford well, and same as to acid from defendant's storage tanks	384	1715
166	Bartell Table showing results of corrosion tests using c. p. (chemically pure) hydrochloric acid solution containing different amounts of copper, lead and iron	394	1716
167	Bartell Table showing effect of agitation and increased quantity of acid on corrosiveness of acid solutions containing different amounts of copper, lead and iron	407	1719
169	Bartell Table showing amounts of copper, lead and iron in defendant's truck (treating) tank acids and storage tank acids	424	1720
170	Bartell's chart showing effect of adding copper, lead and iron to 15.1% c. p. hydrochloric acid	428	1721

All exhibits are printed in Volume IV unless otherwise indicated.

PLAINTIFF'S EXHIBITS

Exhibit Number		Pages Identified	Printed
171	Bartell Table showing percentage reduction in corrosiveness of hydrochloric acid resulting from addition of different inhibitors named in Grebe-Sanford patent	451	1723
172	Data showing dates when samples of defendant's treating and storage acids were taken by plaintiff and dates of receipt of acid by defendant.....	494	1724
173A	Prutton Table showing results of small scale tests of corrosiveness of hydrochloric acid containing different amounts of iron, lead and copper.....	516	1726
173B	Table comparing results of some of tests shown in Exhibit 173A.....	516	1727
173C	Ditto	516	1727
173D	Ditto, and description of tests, materials and equipment used and explanation of tables.....	516	1728-33
176	Prutton Table showing amount of iron dissolved from Series 1 oil well tubing in large scale Run 1A using 15% commercial HCl	508	1734
177	Ditto re Run 1AA	515	1735
178	Ditto re Run 2A using Series 2 tubing	515	1736
179	Ditto re Run 2C using Series 2 tubing	515	1737
180	Ditto re Run 1B using Series 1 tubing and 15% commercial HCl containing small amounts of copper, lead and iron chlorides.	517	1738
181	Ditto re Run 2B. Similar to Run 1B, but with Series 2 tubing.....	517	1739
182	Ditto re Run 2D. Similar to Run 2B, but with different amounts of copper, lead and iron.....	517	1740
183	Ditto re Run 2E. Similar to Run 2B, but with different amounts of copper, lead and iron.....	517	1741
184	Prutton's summary and conclusions with respect to runs in Exhibits 176-183.	534	1742-45
185	Prutton Tables showing results of Runs 1M, 1N, 2M and 2N, using commercial acid from special tank embodying features of defendant's truck tanks	537	1746-49
	Sketch showing equipment used in Runs 1M, 1N, 2M and 2N.....	537	1751

PLAINTIFF'S EXHIBITS

Exhibit Number		Pages	
		Identified	Printed
186	Defendant's booklet re Howco method	587	Vol. II, 587
187	Prutton graph showing results of runs of Exhibits 176-183.....	602	1752
188	Prutton graph comparing results of Runs 1M, 1N, 2M and 2N (Exhibit 185) with average of Runs 1A, 1AA, 2A and 2C (Exhibits 176-179).....	604	1753
189	Prutton graph showing results of tests of 15% c. p. hydrochloric acid with different added amounts of copper, lead and iron.....	605	1754
192	History of oil development in limestone fields prior to 1932 and history of acidizing in those fields beginning in 1932, prepared by the witness Fitzgerald	178	1755-70
195	Item from Montana Oil & Mining Journal for January 26, 1935, reporting increase of production in Pondera (Montana) field, due to acidizing.....	186	1770
196	Bulletin of Montana Oil Conservation Board	189	Vol. I, 187
199	Letter, Dow Co. to Oil Makers, 9-23-32.	1171	Vol. III, 1172
200	Letter, Grasselli to Oil Makers, 10-14-32.	1174	Vol. III, 1174
201	Letter, Grasselli to Oil Makers, 11-1-32.	1175	Vol. III, 1175
202	Letter, Grasselli to Oil Makers, 1-26-33.	1176	Vol. III, 1178
203	Letter, Grasselli to Oil Makers, 9-15-32.	1179	Vol. III, 1179
204	Letter, Oil Makers to Grasselli, 10-8-32.	1179	Vol. III, 1180
205	Oil Makers checks to Penn. Salt Co.	1196	Vol. III, 1196
216	Letter, Lee to Oil Makers, 2-7-33.	1243	Vol. III, 1242
218A-218D	Pages from notebook kept by the witness Sprenger	1257	1772-74
219, 220	Photograph of standing valve and working valve	1268	1775
228	Letter, Prutton to Rebbeck, 1-28-41.	799	1776
231A-231J	Dow Company's records of shipments of acid to Pure Oil Company during period from February to May, inclusive, 1932	140	1777-86
232	Table supplementing Exhibit 94.	845	1787
233	Summary of well treatments made by licensees of Dow other than Dowell.	845	1788

All exhibits are printed in Volume IV unless otherwise indicated.

Exhibit Number	PLAINTIFF'S EXHIBITS	Pages	
		Identified	Printed
234	Sketch and data prepared by Dr. Prutton showing rates of attack on oil well tubing of 15% c. p. hydrochloric acid and of 15% synthetic defendant's treating acid	840	1789
242	Dowell advertisement in Petroleum World, September, 1938.....	846	1790
243	Ditto for January, 1939.....	847	1791
245	Dowell, Inc., Service Price Schedule 110.	852	1792
246	Record of shipments of hydrochloric acid and arsenic inhibitor by Dow Company for period January to June, 1932, inclusive	121	1793
305	Affidavit of Robert Quinlan on the first treatment of a Pure Oil Company well with inhibited hydrochloric acid..	1028	1794
328	Table showing results of acid treatments of gas wells by Dowell, Inc., prepared by the witness Lyons.....	191	1796
329	Ditto, showing additional treatments and data	193	1797
330	Table showing time acid was in tubing in each of 122 acid treatments made by Dowell in Kansas from March to September, 1936, in 97 consecutive Arbuckle dolomite wells.....	197	1798
331	Data showing average time acid was in tubing in making the 122 treatments itemized in Exhibit 330.....	197	1799
337	Chart showing combinations possible under claims of Gravelle Patent 1,678,775.	1320	1800
343	Alquist Table showing rate of corrosion of mild steel in various concentrations of hydrochloric acid.....	1365	1801
	Charts forming part of Exhibit 343...	1365	1802-03
344	Alquist Table showing acceleration of the rate of corrosion of hydrochloric acid containing an acid regulator caused by the addition of tin, cobalt or nickel	1370	1804
	Chart forming part of Exhibit 344...	1370	1805
347	Table supplementing Plaintiff's Exhibit 252	1404	1806
348	Table showing treatments by Dow licensees other than Dowell.....	1404	1807

All exhibits are printed in Volume IV unless otherwise indicated.

PLAINTIFF'S EXHIBITS

Exhibit Number		Pages	
		Identified	Printed
349	Table showing summary of royalty charged by Dow Company to licensees.	1404	1808
350	Table showing quantities of inhibited acid and other materials used by Dowell, Inc.	1405	1809
350A	Graph illustrating data in Exhibit 350.	1407	1810
351	Acidizing orders, tickets and other data from defendant's files relating to wells at which plaintiff secured samples of defendant's truck (treating) acids	1406	1811-24
354	Dowell advertising data for years 1932 to 1934	1407	1825
355	Photograph of one-half gallon container used in Alquist's tests, and table and graphs showing results of tests.	1376	1827-29
356	Photographs of 10-gallon drum and of equipment used by Alquist in making tests, and tables and graphs showing results of such tests.	1380	1830-40
357	Table, graphs and drawing of equipment used by Alquist in making tests showing loss of strength of 15% hydrochloric acid when in contact with iron for different periods up to 24 hours.	1398	1841-46
358	Bartell Table showing summary of corrosion tests of various commercial hydrochloric acids of 15.1% strength. .	499	1847
360	Table showing Dowell advertising 1932 to 1940, inclusive.	1408	1848
362	Poffenberger's report on acid treatment of Dow Company's brine well No. 77	1418	1849-53
363	Poffenberger's report on acid treatment of Dow Company's brine well No. 80	1418	1854
364	Poffenberger's report on tests of inhibiting value of arsenic compounds in hydrochloric acid.	1423	1855
366	Carr and Humphrey patent application for method for increasing fluid production from oil wells.	1427	1857-64

PLAINTIFF'S EXHIBITS		
Number Exhibit		Identified Printed Pages
367	Carr and Humphrey patent application on chemical reagent for use in oil wells	1428 1864-68
368	Carr and Humphrey patent application for method for introducing acid reagents into oil wells by gas pressures	1428 1868-72
369	Agreement between The Dow Chemical Company and The Pure Oil Company dated January 31, 1933.....	1428 1873-77
370	Agreement between The Dow Chemical Company and The Pure Oil Company dated June 30, 1934.....	1428 1877-82

DEFENDANT'S EXHIBITS

8	Excerpts from article by R. Van A. Mills, dated December, 1923, entitled "The Paraffin Problem in Oil Wells".	35 1883
72	Letter from M. G. Harper to J. W. Van Dyke, dated December 5, 1895....	1033 1884
73	Telegram, Harmon to Van Dyke, dated January 24, 1896.....	1033 1885
74	Memo from C. F. Lufkin to Van Dyke, undated.	1033 1886
83	Telegram, J. C. Donnell to Van Dyke, dated November 25, 1895.....	1887
86	Telegram, Harper to Van Dyke, dated December 6, 1895.....	1887
88	Letter, The Grasselli Chemical Company to Van Dyke, dated July 26, 1895	1888
90	Letter, Herrman (Frasch) to Van Dyke, dated September 22, 1895.....	1889
101	Letter, Harper to Van Dyke, dated December 16, 1895.....	1033 1890
102	Letter, Harper to Van Dyke, dated December 16, 1895.....	1047 1891
103	Letter, Ohio Rubber Company to Solar Refining Co., dated September 21, 1895.	1047 1892
104	Letter, Ohio Rubber Company to Solar Refining Co., dated September 25, 1895.	1893
105	Memo re Crossley Well No. 3 of Ohio Oil Company	1047 1894

DEFENDANT'S EXHIBITS

Exhibit Number		Pages	
		Identified	Printed
108	Letter, Harper to Van Dyke, dated February 5, 1896.....	1047	1895
109	Correspondence between Lufkin, Van Dyke and Donnell re acid treatments (July, 1895, and February, 1896)....	1047	1896
110	Letter, Lufkin to Van Dyke, dated July 29, 1895.....		1900
111	Letter, Harper to Van Dyke, dated December 2, 1895.....	1047	1902
112	Letter, Grasselli Chemical Company to Van Dyke, dated November 21, 1895..		1903
113	Letter, Van Dyke to Grasselli Chemi- cal Co., dated November 20, 1895....		1904
114	Memo dated November 21, 1895.....		1905
115	Letter, Frasch to Van Dyke, undated.		1905
132	Letter, Grasselli Chemical Co. to Van Dyke, dated July 19, 1895.....		1906
138	Letter, Lufkin to Van Dyke, dated Au- gust 2, 1895.....		1907
151	Report on scale formation in wells by Blaine B. Wescott.....	1081	1908-21
152	Report by F. W. Karl, dated February 1, 1929, re treatment of William Berryhill Well No. 8.....	1087	1922
153	Same as Plaintiff's Exhibit 153.....	1087	1664-1704
191	Gardner Affidavit	750	Vol. II, 752
221	Letter, Robinson to Prutton, 9-12-39..	769	Vol. II, 769
222	Letter, Rebbeck to Prutton, 1-24-41..	771	Vol. II, 772
223	Letter, Prutton to Rebbeck, 2-19-41..	774	Vol. II, 775
224	Letter, Rebbeck to Prutton, 7-10-41..	791	Vol. II, 791
225	Letter, Rebbeck to Prutton, 7-9-41... 792		Vol. II, 791
226	Letter, Rebbeck to Prutton, 7-9-41... 792		Vol. II, 793
227	Letter, Rebbeck to Prutton, 7-11-41.. 792		Vol. II, 793
280	Hathorn's chart re tests on hard steel tank No. 1.....	854	1924
281	Hathorn's chart re tests on hard steel tank No. 2.....	854	1925
282	Hathorn's chart re tests on hard steel tank No. 3.....	854	1926
283	Hathorn's chart re tests on soft steel tank No. 4.....	854	1927
284	Hathorn's chart re tests on soft steel tank No. 5.....	854	1928
285	Hathorn's chart re tests on hard steel tank No. 1.....	854	1929
286	Hathorn's chart re tests on soft steel tank No. 4.....	854	1930

All exhibits are printed in Volume IV unless otherwise indicated.

DEFENDANT'S EXHIBITS

Exhibit Number		Pages	
		Identified	Printed
287	Index for Hathorn's corrosion experiments	855	1931
288	Photograph of Hathorn's hard steel tank No. 1.....	855	1932
289	Photograph of Hathorn's soft steel tank No. 4.....	855	1933
294	Prior art patents.....	912	1935-88
	Frasch 556,669	68	1935
	Laverty 856,644	913	1939
	Beneker 914,916	915	1941
	Gravell 1,398,507		1943
	Holmes 1,470,225	916	1945
	Gravell 1,678,775	95, 897	1947
	Gravell and Douty 1,678,776.....		1950
	Fischer et al. 1,736,282.....	917	1954
	Rhodes 1,746,677	918	1957
	Rhodes 1,746,678	920	1961
	Vignos 1,750,651	920	1964
	Harrison 1,766,902	921	1968
	Corson et al. 1,773,953.....	921	1971
	Lawrence 1,780,594	922	1974
	Lawrence 1,780,595		1976
	Calcott 1,785,513	923	1978
	Burke 1,789,805	923	1980
	Corson 1,809,621	923	1985
	Carr 1,891,667	76	1988
300	Memorandum given by Grebe to defendant's witness Thomas.....	1012	1993
301	Letter, C. Plummer to The Dow Chemical Company, dated December 1, 1932.	1016	1994-97
302	Memorandum of conversation with Ross T. Sanford, dated December 8, 1932.	1016	1998-99
303	Memorandum of conversation with John J. Grebe, dated December 8, 1932.	1023	2000-02
304	Preliminary draft of patent application of John J. Grebe, dated June 7, 1932.	1025	2002-09
312	File history of Grebe and Sanford patent 1,877,504		2010-46
314	Conception data sheet signed by John J. Grebe July 2, 1932.....		2047

Dr. Carl F. Prutton

DR. CARL F. PRUTTON,

a witness called on behalf of Plaintiff, testified as follows:

DIRECT EXAMINATION

My name is Carl F. Prutton. My residence is 2217 South Overlook Road, Cleveland Heights, Ohio. My occupation is professor in charge of the chemistry and chemical engineering department, at Case School of Applied Science, in Cleveland, Ohio.

As to my education, I received the Bachelor of Science degree, the Master of Science degree, and Doctor of Philosophy. My experience in chemical matters has been connected with both my educational training and industrial experience as a consultant for many concerns. I have been connected with Case for twenty-one years. Electrochemistry is one of the subjects that I have taught for many years.

By Mr. Owen:

Q. Have you conducted any experiments with a view to ascertaining what effect the presence of small amounts of copper, lead and iron in hydrochloric acid solutions has on the corrosive effect of the acid on iron or steel? A. I conducted two sets of tests, to determine the effect of copper, lead and iron in hydrochloric acid solutions, upon oil well tubing. The first set of tests was conducted upon a small laboratory scale; the second series of tests was conducted on a large piping set up, in which large volumes of prepared acids were run through the system. The tests were conducted in the laboratories of the Case School of Applied Science during the last two years, or two and a half years.

The small scale tests were performed in the following manner: One inch sections of $1\frac{1}{4}$ inch type C oil well tubing were cleaned under an exact procedure of cleaning, following the following steps: First, the small sections of

tubing were washed thoroughly with a fifty-fifty mixture of benzene and acetone. Second, immersed in 15 per cent c.c. hydrochloric acid for one hour. Third, rinsed thoroughly in water. Fourth, dried in an oven at 105 degrees Centigrade for one or two minutes, simply to remove the moisture.

The ends of the samples were then carefully faced off in a lathe. The handling of the sample in that operation was done avoiding any contact of extraneous material, handling with metallic tongs, and there was no oil used in the cutting operation. In this manner an exact length of oil well tubing could be obtained.

The sixth step was to brush the inside surface of the tubing with a hardened steel wire brush, known as a flue cleaning brush, which removed any loose particles of metal from the inner surface of the sample. The outside of the sample was burnished on a clean wire burnishing wheel, to remove any loose particles. The seventh step was, the sample was then rinsed in acetone, and then dried in an oven at 105 degrees Centigrade for about one minute, and then cooled in a dessicator, and weighed.

The test procedure was to take these small sections of oil well tubing which had been cleaned in the manner that I just described, and suspended them after, of course determining their initial weight, suspended them in a two liter bottle by means of a glass hook coming through the top of the bottle in the middle of the sample of acid on which the corrosiveness was to be determined. 1360 c.c. of acid were placed in the bottle. The bottle was immersed in a constant temperature bath at 30° C. and when the acid in the bottle had reached the 30° C. temperature the steel sample was then inserted and the test was started. The sample was removed at the end of the three-hour period, was washed with water, then with acetone, and then quickly dried and final weight of the sample determined. The loss in weight from the specimen was then calculated by subtracting the two weights—the difference between the initial and the final weights.

Dr. Carl F. Prutton

The results of these tests were reported in two figures. First, the grams of steel dissolved per square meter of area of the sample per hour of acid contact; and secondly in terms of the percentage reduction in corrosiveness when a given sample of acid was compared with chemically pure acid, exactly in the same manner calculation that Dr. Bartell used in expressing his results.

Q. What acids did you use in these small scale tests?

A. The acids that were used in the small scale tests, first, a determination was made upon chemically pure acid which was diluted to 15% concentration and, of course, the results of that test expressed on the basis of percentage reduced corrosiveness would be zero because it was the blank run. Samples were then prepared from 15% chemically pure acid, which contained various amounts of copper chloride, of lead chloride, and of iron chloride. The chemically pure salts were dissolved in the acid in definite proportions to give a range of compositions that covered the range of compositions reported to us as having been found by Dr. Bartell in his analyses of the defendant's samples obtained in the acidizing of oil wells.

The second test following the blank, the acid contained 15% hydrochloric acid, 473 parts per million of iron in the form of iron chloride, 242 parts per million of lead, and 2.14 parts per million of copper. The percentage reduction in corrosiveness of that acid as compared with the C. P. was 59.7.

The third sample, 15% hydrochloric acid contained 473 parts per million of iron, 242 parts per million of lead, and 3.72 parts per million of copper. The percentage reduction in corrosiveness of that acid as compared with the C. P. was 70.

The fourth sample contained 15% hydrochloric acid, again 473 parts per million of iron, 510 parts per million of lead, and 1.86 parts per million of copper. Percentage of reduction in corrosiveness as compared with the C. P. acid was 62.8.

The fifth sample contained 15% hydrochloric acid, by

Dr. Carl F. Prutton

weight 473 parts per million of iron, 510 parts per million of lead, and 4.18 parts per million of copper. The reduction in percentage of corrosiveness was 71.4.

The sixth sample containing 1430 parts per million of iron, 204 parts per million of lead, and 1.86 parts per million of copper, the percentage reduction in corrosiveness was 61.1.

The seventh sample, 15 per cent HCl, 1440 parts per million of iron, 530 parts per million of lead, and 3.44 parts per million of copper, 70.5 per cent reduction in corrosiveness.

The samples were all run in duplicate and the individual determinations did not vary over one per cent from each other, and the average is reported.

The conclusions from these tests are that copper chloride and lead chloride and iron chloride in the compositions such as reported to me as having been found by Dr. Bartell in the defendant's acids, reduce greatly the corrosive effect of the acid upon oil well tubing, and the reduction is around 70 per cent in this laboratory test. We have made some other tests in which the proportions have been varied somewhat from these figures, but the percentage of inhibition does not change greatly from these.

Q. Well, then, will you compare the results of the different tests you have made, six in number, as compared with the C. P. hydrochloric acid blank, and explain how the effect of varying the amounts or the proportions of iron, lead and copper have affected the corrosiveness of the solution? A. Well, these results would indicate quite definitely that iron has practically a negligible effect in the concentrations that were used here, and if you will look at Test 2, in which 473 parts per million of iron were used and about 240 of lead and a little over 2 of copper, it was 59.7% reduced in corrosiveness. And when the iron was stepped up in Test 6, to 1430 parts per million and the lead was about the same, 204 instead of 242, and the copper was around 2 parts per million, the percentage corrosiveness reduced was 61.1, or substantially the same. In other words, the iron,

Dr. Carl F. Prutton

variation in iron concentration over this range of about 470 parts per million to over 1400, the iron has practically no effect upon the amount of inhibition that is obtained.

With the copper, why, you can see a definite increase in going from Test 2, where 473 parts per million of iron were present and 242 of lead, but only 2.14 of copper gave 59.7 per cent reduction in corrosiveness. In Test 3, when the iron and lead contents were identical and the copper content stepped up to 3.72, or not quite double that in Test 2, the percentage of inhibition went up, or the percentage reduction in corrosiveness went up to 70 per cent. In other words, doubling the copper content from 2 parts per million, approximately, to 4 parts per million, increased the inhibition about 10 per cent.

The lead concentration, if you try to analyze it, it shows some slight increase in inhibitive power, but not nearly as great as the copper, so the iron has practically no effect, the lead has some effect and copper has a very appreciable effect, which agrees with Dr. Bartell's tests.

Mr. Owen: I supposed I had a table showing what the Doctor has been testifying to, and which I intended to offer, but it is apparently not available today. I would like to offer it tomorrow morning.

The Court: You may do that. I want to have it as an exhibit. I will give you a number now. It will be PX-173. (Plaintiff's Exhibit No. 173 was reserved.)

Mr. Owen: You referred to another series of tests which you conducted, more or less approximating conditions which are present in acidizing an oil well. Will you describe those tests and the apparatus and materials you used in making them? A. In the large scale tests we used this pipe "C" oil well tubing, which we purchased from the Oil Well Supply Company of Pittsburgh, Pennsylvania. There are a number of charts and figures. I don't know which ones you want to introduce in evidence.

Mr. Owen: Let us use PX-174 for the drawing showing the apparatus which you used in your tests, and which you are now going to describe.

Dr. Carl F. Prutton

The Court: PX-174 will show this larger experiment, is that it? I am thinking of it as the bigger one.

Mr. Owen: Yes. Now, will you describe the apparatus and the materials, and the manner in which you conducted those large scale tests? A. The apparatus employed was, first, as shown in Figure 2 (PX-174) in this report that I have. In these large scale tests, approximately 200 gallons of 15 per cent hydrochloric acid were run through 112 feet of this 1½ inch oil well tubing—15 per cent commercial hydrochloric acid, and 15 per cent commercial hydrochloric acid to which various metal concentrations were added. The acid was all purchased from the Grasselli Division of the du Pont Company, in Cleveland, and it was regular commercial hydrochloric acid, or muriatic acid, delivered in carboys, and we transferred the acid from the carboys through glass siphon tubes into a stoneware storage crock, and diluted the acid with Cleveland city tap water to the correct concentration of 15 per cent.

Q. The stoneware crock is the one shown in the photograph, PX-175? A. Yes. The stoneware crock used was a brand new stoneware crock, obtained from the Myers-Knight Company, of Akron, and was thoroughly soaked in hydrochloric acid for several days before using it in tests, and between tests was soaked in 15 per cent hydrochloric acid to be sure that there was no contamination from one test to another.

The acid was prepared in that crock, and drained from the bottom of the crock through the spigot into the piping system, and connections were made between the piping system and the stoneware crock by means of pure gum rubber tubing, short lengths, and short lengths of 1 inch Pyrex tubing.

The Court: Is that the part that is the top of the tubing? A. Yes, the top of the tubing. Part Y is the start of the steel tubing. The line connecting to the crock from point Y back to the crock and the line extending up to the top of the crock is all Pyrex tubing, connected with short lengths of rubber tubing wherever connections had to

be made. All of the rubber connections that were used in this work were soaked in hydrochloric acid for several days to make certain no soluble constituents of the rubber tubing would dissolve into the acid on the actual test.

The entire line of tubing was made up of 20-foot sections of this oil well tubing connected together with couplings of the same tubing. The couplings were supplied with the tubing when we purchased it. And elbows were prepared by cutting the threaded ends off of several lengths of the tubing and welding those short sections together to make elbows with threads on them. That length of $1\frac{1}{4}$ " oil well tubing, extending for a total distance of 112 feet, was slightly inclined so the acid would run through it. I think the fall from one end to the other was about six to eight feet in the 100 foot length.

The Court: That is not shown. A. No, this is just a schematic drawing. It was on a slight incline. At the lower end of the oil well tubing, the discharge end, a rubber stopper was inserted into the last length of oil well tubing and through that a short length of 1" diameter Pyrex tubing, and under that a short length of pure gum rubber tubing. Extending beyond that rubber tubing was another short length of Pyrex tubing that dipped into the top of an open bottle. On this rubber tubing we had a screw clamp so we could adjust the rate the acid ran out of that piping system. The bottle had an orifice in the bottom, this discharge bottle that the acid ran into of one-gallon capacity, and by keeping the height of the acid in the bottle at a definite level with this definite diameter orifice at the bottom, the rate of discharge was maintained constant at one gallon per minute, with a definite size hole in the bottom of the bottle, side of the bottle, and a definite liquid in that open bottle running into this tube you get a definite rate of flow. It is a standard method of measuring the flow. The rate of these tests was adjusted to one gallon of acid per minute.

The Court: Your final adjustment was by the size of the stream? A. By the size of the stream, by the height

Dr. Carl F. Prutton

of the liquid column. The higher that liquid would be in the bottle the greater the run out of the hole in the bottom. In other words, we had a constant size orifice.

The Court: The adjustment was by the size? A. By the size, by the screw clamp. The size of the stream was adjusted so that we maintained a definite calibrated level at the bottom. At the top of this system connecting to the Pyrex tubing leaving the crock was a gas vent which permitted the escape of any hydrogen gas from the system. It would simply bubble back up the tube and out of the Pyrex tubing vent at X. We discharged that back into the top of the crock because sometimes the bubbles of hydrogen carry small amounts of acid with it, a little slug of acid would be shot out.

The Court: How did you get it back? A. We just bent the tube over the edge, up over the edge. These tests were run at 85 degrees Fahrenheit. All of the tests were run after the acid was adjusted to 85 degrees Fahrenheit. The results of the tests and the data taken are given in individual tables that have been prepared, and if we take up the first test that was made—before I take up this first test I think it would be well to describe the method of cleaning out this tubing.

The Court: Right in this same book? A. It is described in there, all the methods that we used. It is the first stiff sheet of tabular data there, marked Table I.

The Court: I was wondering if you wanted the whole thing in. It seems like a very carefully worked out and prepared document. I was wondering if you wanted this as an exhibit. I am not trying to outline your course of procedure. I thought before we started using up letters I would ask you whether you wanted it all in. You have got minutes on this one.

Mr. Owen: I have got minutes on this. This is my copy and I have marked it up. Let us consider this tonight.

The Court: Suppose we call Table I Exhibit PX-176. And when we get one that you can spare and want to we

Dr. Carl F. Prutton

will put it in. I will save you the place. Table I is PX-176. (Plaintiff's Exhibit No. 176 was reserved.)

The Witness: The method of cleaning the tubing was substantially the same as was used in cleaning these small specimens that I described in the laboratory test. The first cleaning operation was the washing of the tubing with a solvent, acetone benzene, to get grease and paint and oil off the outside and inside of the tubing, and then the tubing was pickled with hydrochloric acid inside, fifteen per cent, and then washed thoroughly and then reamed out or brushed out with this very stiff flue brush, which was kept very clean and we used a new one on about every second test to remove any very loose particles of metal that may have been on the inside of the pipe.

And the inside of the pipe, when that cleaning operation was over, had a burnished appearance. It was very bright looking, very clean. The outside of the pipe in these tests was not wire brushed as we did in the laboratory test, simple because the outside of the pipe was not exposed to the acid in the large scale tests, but in the small scale tests it was exposed. So we did not give it the same cleaning on the outside.

The tubes and fittings were all accurately weighed, and the accuracy of the weighings was to about two grams, and so we could determine the loss in weight of each fitting and each length of tubing in the test. And the pipes were then carefully assembled, after the cleaning operation and weighing.

The acid was run through the pipe system after it reached a temperature of 85 degrees Fahrenheit, and the rate was adjusted rapidly to one gallon per minute. That was easily done. It occupied a very short time. And then, as the acid ran through the tubing, we took periodical samples of the discharged acid leaving the tubing and saved those samples for analysis and future examination.

At the end of the test, the tubing was taken out and washed, cleaned and re-weighed, dried, of course, and re-weighed to get the loss in weight or a rough check on the

Dr. Carl F. Prutton

loss in weight, but the amount of iron that was picked up by the acid was determined very accurately by analysis of the inlet acid and analysis of the outlet acid during the run.

Now, if we go to Table I, the first run was made using 15 per cent hydrochloric acid, prepared from this Grasselli commercial acid, diluted with Cleveland tap water. Run 1-A, the first column gives the run numbers. The second column gives the general conditions of tests and of the acid used, 15 per cent hydrochloric acid directly from the stone-ware crock through the tubing, temperature of 85 degrees Fahrenheit, at the rate of one gallon per minute, and the Series 1 tubing.

Now, in order to insure that we had made a valid test, we simply picked at random five lengths of this oil well tubing, numbered them carefully and called that Series 1 tubing, and every test in which Series 1 tubing is used has the number 1 in front of it. So 1-A was run with Series 1 tubing. We then picked five other lengths of oil well tubing at random and numbered each length and called those tubes Series 2 tubing, and so every test run upon Series 2 tubing has the number 2 in front of it and the letter following. It is a different tubing. So we ran the 15 per cent commercial acid, 1-A is running 15 per cent commercial acid through Series 1 tubing, and then we took this other set of tubing, completely different, and we ran commercial acid through it. So we have two separate, completely separate sets of tubing, and we kept those sets together in the subsequent runs.

The first run, 1-A, shows a run with the commercial acid diluted to 15 per cent concentration, temperature 85 degrees Fahrenheit, and in the third column in this table are the gallons of acid through the tubing between samples.

Now, we took a sample about every 20 minutes, of the effluent acid, and at that time, at the time of taking the sample of effluent, we determined the number of gallons of acid that had run through the system by noting the fall of level of acid in the crock. We could calculate the amount that had gone through. So at the time that $27\frac{1}{2}$ gallons

Dr. Carl F. Prutton

of acid had run through the tubing, if you follow over you will see that the sample No. 1, in the samples taken at the outlet, is opposite that particular volume of acid that was discharged, and so every 20 minutes we took a sample of the discharged acid.

At the start of the test, each of these tests, the first gallon of acid that came through was distinctly dark. It had a darker color than the rest of the acid, and we found in each case the initial acid that came through, the first gallon, definitely contained a greater amount of iron than the rest of the acid taken at subsequent times. But that concentration of iron in that first gallon, although it was high, was not an appreciable part of the total iron dissolved. It was a very negligible part, and we have shown in these tables, just to make them complete, we have shown the concentration in that first gallon of acid.

The Court: Now, that acid you took where? A. We took it down at the bottom. It just ran out of the bottom through the whole piping system.

The Court: All through the pipes? A. Yes, and we took a sample out of the first gallon of acid coming through, which was a little darker than the rest. After that it cleared up and got a certain definite yellow color, due to the iron, and our iron analysis fell down to a fairly stable value, and we took a sample every twenty minutes of the discharged acid, and we took two samples, as shown in the fourth column under the general heading of samples taken at the inlet, the fourth major column, samples taken at the inlet.

The Court: That is way up at the top? A. At the crock. We took two samples, one at the start of the run and the other at about half way through the run. Those two samples were blended together to make a composite sample, composition of the acid leaving the crock, just to save analysis.

The Court: You didn't analyze that? A. We did not analyze each separately. We mixed the two together. We took an equal volume of each.

The Court: I took it from what you said this is in the

Dr. Carl F. Prutton

initial test? A. In the crock. They should be just alike. There was no necessity of checking each one. The composition of that inlet acid is shown in this sub-head, specimen Fe, under the fourth column of samples taken at the inlet, and the next column with the sample number.

The Court: 9.3 parts iron to a million parts of acid? A. Parts of acid.

The Court: Of the whole solution? A. That is correct. Now, under samples taken at the outlet, the first sub-column and sample number, the initial sample out, that was the first gallon of acid coming through, was slightly darker than the rest. Then a sample was taken at the end of twenty minutes and at twenty minute intervals thereafter. Those 20-minute samples were blended together to make composite samples.

The Court: Not the first one. A. The first one wasn't considered. We took one sample right at the start. The first gallon of acid through we took a sample. That is the initial out. No. 1 is the first sample taken at the end of the first twenty-minute interval. The initial out is the sample of the first gallon of acid that left the tubing.

The Court: Well, what is No. 1? A. No. 1 was taken at the end of twenty minutes, at the end of the run.

The Court: All right. Now I've got you. After that initial out you bunched three together. A. 1, 2, 3; then 4, 5, 6, and then 7, 8, 9 and 10 were bunched together in proportion to the volume that had run through the pipe at the time analysis was made for the iron content in those effluent samples or composite samples and the parts per million of iron is reported in the second sub-head under "Samples Taken." The initial sample out, 2240 parts per million of iron; the first composite sample of 1, 2 and 3, 1135 parts per million; the second composite sample 4, 5 and 6, 1450 parts per million; the third composite sample, 7, 8, 9 and 10, 1405 parts per million.

The Court: Now I am curious to know that there is a peculiar curve there. It is a way up and down, then up and then down. I am wondering if you had analyzed each one

Dr. Carl F. Prutton

of those samples whether you would get another little hump in there. A. The initial out is very easily explained. In the burnishing operation and cleaning there were little particles that dissolved rapidly so that shouldn't be considered. The subsequent, although there is some variation, the variation is not a great deal. I think particularly in the last two samples—1450 to 1405 is not a great deal, and the 1135 that, of course, is lower than the 1450.

The Court: What do you think No. 1 would be as compared to No. 3? A. Well, it might be 10% difference—something like that; maybe 100 parts per million.

The Court: One or three? A. I think No. 1 would be lower than No. 3, possibly.

The Court: In other words, you think that that first gallon out had gotten out all the loose stuff? A. All the loose material.

Mr. Owen: I might call your attention to the fact that in subsequent tables, II, IV and III, which were all run with commercial acids without any additions of metals, the same ratio or the same phenomenon appears in I, II and III. That is, the first initial out sample is high in iron and then the next three, the composite is lower than the second three, and the final four drops off a little from the second three of that sample that run through the series.

The Court: What you found was not free iron but ferrous what? A. Ferrous chloride.

Mr. Owen: Now, Doctor, explain the entry in the last column. A. The last column report is the number of grams of iron picked up by the acid in running through the tubing. The amount of iron at the inlet acid was calculated and the amount of iron at the exit was calculated and the difference shows an increase in iron content and it amounted to 1043 grams of iron or a little over two pounds of iron dissolved.

The Court: In other words, if you take this ferrous chloride and bring it up so you didn't get your free iron you would have two pounds? A. You would have two pounds of metallic iron. Ferrous chloride is FeCl_2 . Now,

Dr. Carl F. Prutton

the second table, Table II in the first column, the run number is given as 1-AA, the "1" designating it as Series 1 tubing. The run 1-AA was a blank run of fifteen per cent commercial hydrochloric acid of the same type described in the first run, run on Series 1 tubing, and the conditions were exactly the same as in the first run. And in this case the initial crock acid contained four parts per million of iron, and the composite samples taken at the exit during the run, the initial out, was 3,540 parts per million. The first composite 1180, the second composite 1263, and the third composite 1218 parts per million of iron, making a total of 943 grams of iron dissolved in that particular test from the tubing.

Then in Table III we ran this diluted 15 per cent commercial acid through the second series of tubing, using entirely different tubing than Series 2 tubing, so in Table III we have run 2-A, "2" designating the series of tubing, and "A" designating a blank commercial fifteen per cent acid. The temperature, rate of flow and so forth was the same as in the other tests. The inlet iron concentration in the acid, the acid going in contained 9.3 parts per million of iron, and the samples of acid leaving the system, the initial out, 3,580 parts per million of iron, the first composite sample 1292 parts per million, the second composite sample 1357 parts per million of iron, and the third composite 967 parts per million. The total amount of iron dissolved from this tubing was 919 grams. Then on Table IV we have a duplicate blank run with a smaller amount of acid. This is run 2-C of Table IV. The 15 per cent acid was run through from the stoneware crock in the Series 2 tubing at 85 degrees Fahrenheit. The composite of the crock sample was 7 parts per million iron. The analysis of the two samples, the initial acid out, 1330 parts per million. The first composite sample, 1143 parts per million of iron. The second composite sample 1088 parts per million of iron. Third composite sample 1070 parts per million of iron. And the total amount of iron dissolved, 791 grams. So there are the results of four blank runs.

Dr. Carl F. Prutton

The Court: I don't consider it of any importance, because it is so small, but it does show that there was less than half as much iron in the crock in the sample in Table II. They got down to half. A. We had purchased several batches of acid, and it varied somewhat from the one shipment to another.

The Court: Each one of these acids are different purchases? A. No, not each one. I have a record of our purchases, and sometimes the purchases overlap the runs. We didn't run the same acid through two runs. We purchased several batches of acid from the Grasselli Company and if we had three or four carboys left over, we used those three or four and it possibly went into the next shipment.

The Court: It was so little I didn't consider it important. I didn't count it as being important. And yet I was curious if it was the same purchase at the same batch how it would have to vary even that much. Do you know whether those were the same purchases? A. I don't think I could tell. I could not tell.

Mr. Lyon: Can I ask if these different batches or different purchases of raw hydrochloric acid were checked against any C. P. blanks so that you could tell the difference? A. We have analyses and inhibition tests of every batch of crock acid that was used in every run that was made.

Mr. Lyon: Against C. P. acid? A. Against C. P. acid and analyses. They are not in the report.

The Court: But you have those figures? A. We have those figures, if they want them. They were substantially in every run within a few per cent of the corrosiveness of C. P. acid, the commercial acid that we obtained from Grasselli.

Mr. Owen: I would like to have the Tables II, III and IV marked as PX-177, 178 and 179 and offered under those numbers.

(Plaintiff's Exhibit Nos. 177, 178 and 179 were thereupon reserved.)

The Court: I don't believe anything has been offered.

Dr. Carl F. Prutton

I think I will say Exhibits 1 through 179, inclusive, have been admitted.

Mr. Owen: Before going on with the examination of the witness, if Your Honor please, I think it may be well to identify these tables that we were going to offer; and I will state that a copy of this report was handed to defendant's counsel just before the adjournment last evening.

Now, PX-173 was a table to be supplied, and I find that on this report, pages 7, 8 and 9, are several tables which I had intended to combine as that exhibit, so I suggest that the table on page 7 be marked PX-173-A.

(The table in question was then marked PX-173-A.)

Mr. Owen: Then on page 8 there are two tables which I will have marked PX-173-B and PX-173-C; and on page 9 there is another small table which I will have marked PX-173-D.

(The tables above mentioned were then marked PX-173-B, 173-C and 173-D.)

Mr. Owen: Then, Your Honor, to identify the other exhibits in this report, the exhibits which were identified last evening, PX-174 is on page 34 of the report. That is the drawing of the apparatus.

On page 35 there is an enlarged detail of the delivery end of the apparatus, and I would like to have those both included in this exhibit, marking page 34 as PX-174-A and page 35 as PX-174-B.

(The pages above mentioned were then marked PX-174-A and 174-B.)

Mr. Owen: Then PX-175 is the photograph of the crock, which is on page 33.

(The photograph was then marked PX-175.)

Mr. Owen: PX-176 is Table I, which is on page 25.

(The table above mentioned was then marked PX-176.)

Mr. Owen: PX-177 is Table II, which is on page 26.

(The table above mentioned was then marked PX-177.)

Mr. Owen: PX-178 is the table on page 27.

(The table above mentioned was then marked PX-178.)

Mr. Owen: And PX-179 is the table on page 28.

(The table above mentioned was then marked PX-179.)

Dr. Carl F. Prutton

Mr. Owen: Doctor, at the adjournment last evening you had discussed your Tables Nos. I, II, III and IV. Can you state what the average loss of weight, or, in other words, the average amount of iron taken up in the acid as it passed through the pipe would be for these four runs, basing it on so many grams per hundred feet of tubing per hour of contact between the acid and the tubing? A. I have those figures here. In runs 1-A and 1-AA, taking first 1-A, the amount of iron dissolved from the tubing, expressed in grams of iron per hundred feet of length of tubing per hour of contact was 289 grams. In run 1-AA the rate of dissolving the iron per hundred feet of tubing per hour of contact was 273. So in the first set of tubing, that is, tubing in Set No. 1, why, the average was 281 grams.

And in the second series 2 tubing runs, with the commercial 15 per cent acid, run 2-A, the rate at which the iron dissolved per hundred feet length of tubing per hour of contact was 256 grams of iron. In run 2-C the rate of dissolving of the iron per hundred feet length of tubing per hour of contact was 239 grams. And the average on that tubing was 248.

Q. And have you the average for the four runs? A. You could. You could average 248 and 281. It would be $264\frac{1}{2}$.

Q. Did you make runs similar to those covered by your tables Nos. I, II, III and IV, in which you made additions to the acid? A. Yes. Those results are reported in Tables V, VI, VII and VIII.

Mr. Owen: I might as well at this time mark those tables as exhibits. Table V as PX-180. Table VI will be 181; Table VII, 182, and Table VIII, 183.

(The tables V, VI, VII and VIII were thereupon marked respectively PX-180, 181, 182 and 183.)

Mr. Owen: Now will you explain in connection with your Table V what that one was, how it was conducted? A. The run 1-B which is reported, or the data reported on Table V, the commercial acid was diluted in the stoneware crock to 15 per cent concentration and metallic chlorides,

Dr. Carl F. Prutton

that is iron chloride, lead chloride, and copper chloride were added to correspond to the composition of defendant's acid as reported by Professor Bartell. Those amounts of metallic chloride were added to the acid. The acid was agitated and before running the acid through the tubing system, why, a chemical analysis was made upon the acid to determine the metallic concentrations, to check on the weights of chemicals that had been added.

Mr. Lyon: Did he add the total amounts that were found in the defendant's well samples or did he add the amounts that represented the difference between the defendant's well samples and the amounts that were in the raw commercial acids? A. We added the difference between the amounts found in the commercial acid and the figures as reported here. In other words, we added the amount of copper, lead and iron that would build the final concentration up to the figures we desired.

Mr. Owen: And what were the figures to which you built up the acid? A. The figures we built up the acid to correspond to the compositions that Dr. Bartell recorded as having been found in the defendant's samples.

Q. Well, for the purpose of the record, it is in the record, but to get it in connection with your testimony, please state to what copper and lead content you built up this acid before running it through the pipe. A. The contents are all reported on the sheets and therefore if I can go through those it would specifically give those concentrations and there will be no question about it.

Q. Well, now, as I understand, figures indicated on Table V at the bottom of the second column show the amount of lead and copper contained in the solution at the beginning of the run. A. That is correct.

Q. Now before we go into this, I will ask you if you analyzed these commercial acids as you received them or if you tested them for inhibition? Please state just what you did and what you found. A. The commercial acids were not analyzed as we received them. The commercial acids were analyzed after they had been diluted to 15% concen-

tration in the crock just prior to adding the chemicals to the acid. The reason for doing that, of course, was we used approximately 8 carboys of acid and we wanted to be sure that the acid that we finally had in the crock before we added the chemicals was representative of commercial hydrochloric acid diluted to 15%. Therefore, the analysis was performed at that time to insure no other impurities had gotten in in the transferring of the acid from the carboys to the crock and in the dilution of the acid. And so we analyzed the acid at the time after it had been diluted to 15% with tap water before these other chemicals were added.

Q. What amount of inhibitor, or what amount of inhibition did you find in the commercial acids as diluted to 15 per cent? A. The per cent inhibition as found in laboratory tests on this diluted 15 per cent acid ran from 0 per cent to a maximum of $6\frac{1}{2}$ per cent inhibition, when compared in corrosiveness with 15 per cent C. P. hydrochloric acid.

Q. And those figures you have just given are for the solutions which you used as they existed before the runs were made, is that right? A. That is correct. Before any additions of metallic salts were made.

Q. Now, will you explain your Table V?

Mr. Lyon: Can I ask one question, Mr. Owen? The witness said that this figure at the bottom of column 2 corresponded to some figure that Dr. Bartell had given. I am unable to find in Dr. Bartell's reports where any of the samples of defendant's well acid that he analyzed, which he reports for these parts per million of lead and copper, so I am unable to understand what figure Dr. Bartell gave to the witness. A. I would like to correct the statement I made prior. Two of these runs, that is, of these runs with synthetic chemicals, were made to duplicate acid which we prepared in a Menaul tank which contained a lead sheet. We duplicated the Menaul tank system of the steel tank and lead sheet at the bottom which was being used to transport their acid, and we will report on those tests later, and

Dr. Carl F. Prutton

we got a certain composition of acid out of that tank, which differed somewhat from the field samples that were reported, so two of these tests are tests in which we ran the same composition of acid that we got out of that Menaul type tank, which did not differ greatly in the composition of the inhibiting metals from the field sample analyses as reported by Dr. Bartell, so two tests are run upon synthetic acid mixtures duplicating the Menaul type acid that we obtained out of the Menaul type tank, and two of them duplicate the analyses as reported to us by Dr. Bartell through Mr. Rebbeck of the Dow Company.

Mr. Owen: I think it is a matter of little importance whether these metal contents correspond exactly with Dr. Bartell's figures, or not. What these tables show is the effect of the presence of the amount of copper and lead which are specified in the tables, and whether they exactly agree with some other tests I do not think is important, so I will ask the court and the witness to consider these tables individually, and explain just how much copper and lead were in each of these runs—how much copper and lead were contained in each of these runs.

The Court: I am not to understand, as I understand it, that your Table V is exactly according to the formula of the defendant's acid, as analyzed by Dr. Prutton? A. It is not.

The Court: It is a synthetic one that you made? A. It duplicates an acid that we made in a Menaul type tank.

The Court: You analyzed it, and this is what it had in it? A. Yes.

The Court: This really is the explanation of it, you made a synthetic acid in this way, and you are going to show the results?

Mr. Owen: That is right.

The Court: That is all you claim for it? A. Yes.

The Court: All right. That is fair.

The Witness: In the first column the run number is 1-B. The acid was prepared, and contained 390 parts per million of lead, 2.79 parts per million of copper, and 1682 parts per million of iron. The figure for the iron is given

Dr. Carl F. Prutton

over under the fourth column, and samples were taken at the inlet, under parts per million of iron. It is the second sub-head under the fourth column. It is the average of two samples taken during the run. This acid was prepared and had those compositions, and then it was allowed to run from the crock through the tubing system that I described previously; and the samples of exit acid were taken and analyzed for iron; and the concentrations of iron in the exit samples are given in the fifth major column, the second sub-head, parts per million under samples taken at the outlet. The initial sample was 3250 parts per million.

The first composite sample was 1990 parts per million. The second composite sample, 2010 parts per million. The third composite sample, 1942 parts per million of iron. Calculating the grams of iron dissolved by the acid in passing through the pipe, there were 238 grams of iron dissolved from the piping system in the test.

The Court: That is, free iron? A. That is free iron. This is calculated as free iron. The weight of the iron dissolved from the pipe is actually that 238 grams. 238 grams is very close to a half pound. On the blanket run in this same tubing, that is the one with just the commercial acid without these added chemicals, and they are numbered 1-A and 1-AA, there were about two pounds of iron dissolved; and when we put those added chemicals in, it cuts it down to about a half a pound of iron dissolved.

Q. Will you take up your Table VI, PX-181, and explain it? A. Table VI is acid that was prepared to duplicate our synthetic Menaul acid prepared in our Menaul type tank. The run number is 2-B. The acid contained 316 parts per million of lead; 3.07 parts per million of copper and 2315 parts per million of iron at the inlet. We ran the acid through in the same manner, and the outlet samples, the samples leaving the end of the tubing system, initially showed 5970 parts per million; the first composite sample 2750 parts per million, the second composite sample 2770 parts per million and the third composite sample 2610 parts per million of iron. Calculating that into grams of iron dis-

Dr. Carl F. Prutton

solved from the tubing by the acid, it is 299.8 grams of iron dissolved, or again very close to a half a pound.

Q. Now, taking up your Table VII, PX-182, please explain it.

Mr. Lyon: Can I ask a question about Table VI. Is Table VI another run of this raw acid in a Menaul type tank? A. Oh, no. This was no Menaul type tank at all. It was run from a stoneware crock through tubing. That is all that was done.

The Court: That is what I thought.

Mr. Lyon: I understand your explanation to that effect, but Table No. VI is like Table No. V in that you determined the amount of copper and lead you added to the raw acid from your tests with the Menaul type tank, rather than from the directions given to you by Dr. Bartell? A. Oh, yes; that is correct.

The Court: He made this synthetically, and what he made it to was not something that Dr. Bartell had made, but something he had made by the experiment that we are going to compare, so far as it does compare, with the way the defendant treats and carries its acid. A. That is right; that is correct.

The Court: I have got the theory of your experiment.

The Witness: We wanted to find out whether that composition of acid, when separated from the lead plate and steel tank, would stop the corrosion of the tubing.

The Court: Where we got started wrong, in some way we got the idea that these had to do with the figures Dr. Bartell had given you, and you synthetically made up to what he had, and all we had to do was to disabuse our minds of that. A. In Tables VII and VIII we are going to take up that type of test.

Mr. Owen: Well, now, take up Table VII, doctor, and explain that. A. In Table VII, the composition was adjusted to the composition as reported by Dr. Bartell as existing in the average of samples he had analyzed of the defendant's acid.

Mr. Lyon: I want to just stop there. I have been

Dr. Carl F. Prutton

having trouble last night finding anything in Dr. Bartell's figures that corresponded to those the witness has given.

Mr. Owen: I will say it is not going to be claimed these exactly duplicate Dr. Bartell's findings. Let me explain. Mr. Rebbeck wrote to Dr. Prutton and told him what the averages of the samples taken from the defendant's wells were as to their metallic content. Dr. Prutton started from that point. Now, whether the actual amount in parts per million of copper and lead in Dr. Prutton's Tables VII and VIII correspond in the minutest detail to the number of parts per million Dr. Bartell's tests average up, I can't say, but I do say that the figures will show for themselves, if we compare Dr. Bartell's figures with these and they are a few parts over and under.

The Court: And we will be able to do that and if they are a little bit off, we will have to adjust them a little.

Mr. Owen: That is the position I take, Your Honor.

The Court: All right. Go ahead on that premise.

The Witness: Table VII, we have run 2-D. The composition of the acid was made up and the final acid before running it through the tubing contained 455 parts per million of lead, 3.7 parts per million of copper, and 418 parts per million of iron. The acid leaving the system, the initial acid out, contained 2295 parts per million of iron, 688 parts per million of iron in the first composite sample; the second composite sample, 697 parts per million of iron; and the third composite sample 669 parts per million of iron. The total amount of iron picked up by the acid was 195 grams. That figure is somewhat less than I found in the iron.

The Court: Let me see, how did you get that 195, by actual weight? A. We actually count them, the volume and acid that has gone through in between taking these samples, and the increase in iron content.

The Court: Did you compute them separately for each one of those four figures of iron? A. We computed the amount of iron. We computed them separately.

The Court: You took that first gallon that went through and computed at that high rate? A. Computed

Dr. Carl F. Prutton

each one of them separately, and then we computed the other quantities of iron at the total volume of inlet acid, and the difference between the sum of these exit acid composites and of the inlet acid, that difference was the amount of iron dissolved.

The Court: Here is what I was getting at, not whether there was anything wrong about your averages. As I understand it, you didn't take an average of four at all, but you took the first run there, and what did that figure, 2995? A. Yes.

The Court: You took all included within the next three sample all at this average figure of 688? A. That is the figure of 62.7 gallons of acid which had run through at that time.

The Court: Then you computed all that ran through during the next three periods at 697? A. That is correct.

The Court: All at the other three periods at 667. A. That is right, and added them together.

Mr. Owen: Would Your Honor like to know how he converted these parts per million into grams?

The Court: Yes, I would.

Q. Will you explain that? A. We have a sample calculation. This is for run 1-A. It is in the report, on page 16, and at the time of taking the first composite sample the gallons of acid that had gone through the tube was $76\frac{1}{2}$ gallons. And went from zero to $76\frac{1}{2}$, and in the acid there was one hundredth of a milligram of iron per cubic centimeter of acid.

The Court: Yes. A. That is we recorded our analyses that way, not quite parts per million. It is a different method of recording. One hundredth of a milligram per cubic centimeter of acid, and that was the inlet acid. The exit acid contained 1.22 milligrams of iron per cubic centimeter, and therefore the difference came in with .01 and came out with 1.22, which was 1.21 milligrams of iron per cubic centimeter.

Now, if we take the total number of cubic centimeters that have gone through $76\frac{1}{2}$ gallons, a gallon is 3785 cubic

Dr. Carl F. Prutton

centimeters, and 85 cubic centimeters, one gallon is 3785 centimeters, so we multiply the gallons times 3785 and we get the total number of cubic centimeters that have gone through during the time of taking the composite sample that we have reported here. That is the total number of cubic centimeters. Now, each cubic centimeter picked up 1.21 milligrams of iron, and therefore we multiply that by 1.21 and we get the total number of milligrams of iron dissolved by that $76\frac{1}{2}$ gallons of acid running through, and then you divide by 1000 and we have the number of grams of iron picked up for that first slug of acid, $76\frac{1}{2}$ gallons dissolved 350 grams of iron.

The Court: Then you did the same thing on the others and added them together? A. Yes, that is right.

Mr. Lyon: I am still somewhat in the dark on one question, to which I would like an answer. I am just trying to get an explanation of this, that is, the final amount of lead and copper as reported at the bottom of column 2, Tables VII and VIII, is quite different. If those are both based on something from Dr. Bartell, I would like to know what accounts for the difference.

The Court: To date, we are forgetting that it is from Dr. Bartell at all, as I understand. A. I would like to explain that difference. In preparing these acids and dissolving the chlorides in the acid, it was very easy to get the iron chloride in the solution, and we could get whatever we wanted in the iron chloride concentration. To dissolve the copper chloride and get an exact copper concentration was also very easy; and, as has been reported by myself and Dr. Bartell, the copper is the vital element in the inhibition. The lead contributes some inhibition, but it is not nearly as vital as the copper concentration.

The Court: But it needs the copper to do its own work, does it not? The lead needs the copper to be effective, does it not? A. The two cooperate, but just the extent of the cooperation is difficult to tell from any tests that have been made; but they seem to cooperate, both contribute an inhibiting effect, but the copper seems to be the

Dr. Carl F. Prutton

one that does the major part of the inhibiting. If we take the final mixture, if we drop out the lead and iron, the copper would almost do what all three do. In dissolving the lead chloride in the acid, it is not very soluble—the concentration that we do get is almost a saturated solution, and, therefore, it was very difficult to dissolve lead chloride and get exactly what we wanted in the final acid, due to that slow rate of solution. And we did not feel that if we missed the lead concentration by 50 or even 100 parts per million that it made a great deal of difference, because the lead, although it has an inhibiting effect, our laboratory tests had shown that going from 250 parts per million to 500 parts per million of lead did not change the amount of inhibition to any extent. Oh, maybe 1 per cent. And therefore, if we hit fairly close on the lead, if we got the copper exact, and hit fairly close to the lead, as close as we could due to the difficulty of getting it in solution, and the iron is immaterial, but we could hit that whatever we wanted to, because it dissolved readily, and the lead is the one we couldn't get exactly what we wanted, due to this difficulty in soluble effect, and therefore the lead will differ. And so the figure that was given to us as the composition of—through Mr. Rebbeck, the average composition of defendant's acid as found by Dr. Bartell, as I stated, as he stated in his letter, 3.8 parts per million of copper. Well, on run 2-E, which is in Table VIII, the acid was exactly 3.8 parts per million of copper. In run 2-D the acid was 3.71 parts per million of copper which was substantially identical. The lead, however, in run 2-D was 455 parts per million, whereas in the analyses it was lower than that. I don't recall the exact figure. The amount that we had in run 2-E was 340 parts per million of lead. But our laboratory tests and the tests of others indicated the lead to be varied from 250 parts per million to 500 parts per million and the corrosiveness or inhibition of the acid was substantially identical.

The Court: Now is that true without the presence of copper, or in any acid with the presence of copper? A. It is substantially true whether there is copper present or not.

Dr. Carl F. Prutton

Mr. Lyon: Your Honor please, I would like to call your attention, while you are considering that, to one thing. The witness, as I understood his explanation to you, said the significant thing was the amount of copper. And you could disregard the lead.

Mr. Owen: No, no.

Mr. Lyon: Well, not disregard it, but—

The Court: But small differences.

Mr. Lyon: Yes. Well, now, I call your attention to Tables VII and VIII. They have apparently almost the same identical amount of copper, and yet the rate of corrosion in Table VII seems to be almost twice that of Table VIII, so there is something wrong here.

The Court: He hasn't got to explaining that. I could draw, probably, the same conclusion you have, to just look at it, but I am not going to until I hear what he says about it.

Mr. Owen: If I can get along, first I want to explain this matter of Dr. Bartell's sample that has been questioned, and if Your Honor will turn to your Exhibit PX-169 and go over to the right hand portion, under the heading "Truck Acids," it gives in that, under the heading, first the Stella Wilcox, then the Zahn and down below, in the separate column, the Crawford, and over to the left of the exhibit, the first line is copper. The first figure of 15 grams, or 3.6 parts per million, shows how much copper there was in that Stella Wilcox sample. And then to the right of that, under Zahn, 13 grams or 3.1 parts per million, was how much copper there was in the Zahn sample. Then if you drop down under Crawford in the first column it shows 20 grams or 4.8 parts per million. The average of all three copper contents is 3.8 parts per million. The amount of copper in Dr. Prutton's Table No. VII is 3.7 parts per million, and that in his Table No. VIII is 3.8 parts per million, so that is about as close as anyone could be expected to get.

Now under the lead content, the second line of figures, under truck acids, is the Stella Wilcox, lead 1700 grams or

Dr. Carl F. Prutton

417 parts per million; under Zahn 1800 grams or 435 parts per million; and under Crawford is 220 grams or 53 parts per million, and the average of those is 301 parts per million. Dr. Prutton's Table VII has 455 parts per million of lead and his Table VIII has 340 parts per million of lead.

Now, if you look at the next line below it shows the iron content, and under Stella Wilcox it was 1900 grams or 473 parts per million; and in the Zahn 1500 grams or 380 parts per million of iron, and under Crawford it was 860 grams or 210 parts per million. The average of those was 354 parts per million. And in Dr. Prutton's Table VII he had 418 parts per million of iron, and in Table VIII he had 382 parts per million of iron.

Exhibit PX-160 is Bartell's own averages of these samples. Your Honor will see they are very close to Dr. Prutton's.

Mr. Owen: Now, Doctor, will you go on with your explanation of Table VIII? A. Table VIII, Run 2-E is reported. The lead content of the acid 340 parts per million, the copper content 3.8 parts per million, the iron content 382 parts per million. The exit acid leaving tubing system, the first composite sample, 550 parts per million. We didn't take the initial out. That amount was of such a small volume, although it may be high, is negligible in comparison with the total and the first acid sample includes that.

The Court: If you made that very small and part of it got over into this No. 1, that, of course, would bring that 550 a little higher? A. A little higher, yes. One gallon out of 191 gallons, no matter how high it is, practically makes no difference. The second composite sample, 508 parts per million of iron; the third 483 parts per million of iron; the total amount of iron picked up by the acid was 101.4 grams.

The question was raised as to why this figure was 100 grams and the other was 195 grams. The statement is made that the acids should give substantially the same amount of inhibition. When you have an inhibited acid and you compare the difference between percent of inhibition and 100 percentage, you get into small differences and you can

Dr. Carl F. Prutton

magnify interpretations to get a very erroneous picture. The picture that these tests present to me is, first, that we ran commercial 15% hydrochloric acid through the tubing and got a loss of about 2 pounds of iron; secondly, we ran commercial acid to which we added the metal contents, varied somewhat, we got from one-quarter to a half pound of iron—approximately that range. It is impossible to exactly duplicate the preparation of the surfaces of the tubing in each run, and therefore I do not believe that the figures given in this report are any more accurate than plus or minus 75 grams, or some figure like that.

In other words, that there is a variation between the preparation of the surfaces that has to be considered and therefore you should look at the thing in a broad way in taking into account the accuracy of the method and the variations that might occur in the preparation of the inside surface of 20 foot lengths of tubing. I really was surprised at the accuracy we really got in comparing these tests.

The Court: This is about a sixth of a pound? A. No, about a quarter of a pound. And the other sample of 195 is about .4 pounds, the other close to .5. So it is between $\frac{1}{4}$ and $\frac{1}{2}$. All of these synthetic acids run in that range. So comparing these two—

The Court: From the corrosive standpoint— A. As I say, I don't believe that these results are more accurate than plus or minus 75 grams as the outer limit of accuracy and that here we got 195 and 101 grams as the amount of iron dissolved.

The Court: You dissolved much less iron. About half as much? A. That is correct.

The Court: So if it will do the other work it would be much more desirable? A. Yes.

Mr. Lyon: May I ask what that means, Your Honor? He says that his results might be off or not accurate by 75 grams. That would mean in the case of Table No. VIII that the results are inaccurate to what per cent? I mean what per cent could you say the test was accurate? A. No, I would say that the test—I have not tried to compute any

Dr. Carl F. Prutton

per cent accuracy because I don't think it is possible, but the interpretation of the tests you have to include a consideration of the variables that are involved in the test, and I would say that this particular test, the actual amount of iron dissolved I am sure is 100 grams or very close to that at least. It might be somewhat more. We did not include the initial sample, due to some error. That would have stepped up a little bit the iron and it might be 150, or something like that. Actually in the weight loss of the tubing it was closer to 200. We weighed the tubing, and in this check we got this 101 grams dissolved in solution by our analysis, but when we weighed the tubing the loss in weight of the tubing was closer to 200 grams, so I would say it was somewhere from 100 to 200 grams of iron dissolved. The average would be about 150.

The Court: It is sort of an experiment if you wanted to check yourself by running two experiments you would have to rig up the thing the second time? A. Yes.

The Court: You couldn't keep using that over and over, the same tubing? A. We used the tubing over and we have data to show that. We have run a series of laboratory tests with this 1¼ inch tubing, running one run with an acid and getting the inhibition or corrosiveness of the acid, then taking it and putting it through this cleaning and brushing operation and running it over again, and we can check with that reuse of the tubing, we can check within about 10 per cent, within about 10 per cent.

The Court: Do I understand you have performed experiments that would be duplicates of this here? What I had in mind was as to your frank statement as to accuracy. I was wondering if I was to understand from that that it is your opinion that if you tried to run the very same experiment there during several times there would be— A. Differences.

The Court: A difference. Then it gets down to about what per cent? A. Oh, it is about 10 per cent.

The Court: Isn't that what you were asking?

Mr. Lyon: Yes. Although of course an error of 75

Dr. Carl F. Prutton

grams in the case of Table No. VIII would be bigger than a 10 per cent error. A. That isn't the statement, or else I made it wrong. I don't believe that 100 grams could be 25 per cent, I don't think that. It was actually 101 grams increase in iron as determined by analysis. That is fixed. But there might be more dissolved than that, somewhat more, and it might be 75 grams more. That is about what I meant.

Mr. Lyon: You made that statement which puzzled me last night, that you find more loss of iron on weighing the pipe than you can find present in the acid in all these tests? A. I will tell you why that is true, because before re-weighing the pipe when we clean it out the inside surface will rust slightly, and very rapidly after washing with water, and we ran that reamer in and dried it again and it took out a little loose iron, and we got more iron out, so the weight loss, we do not rely on that.

We can absolutely rely on these chemical analyses as being within 10 per cent of the figures, and we are talking here about 70 and 80 per cent reduction of corrosiveness, and 10 per cent on that is not a major factor, in a practical sense. If we were down talking of 10 per cent inhibition, 10 per cent would be a major factor. We are talking about 60 and 80 per cent.

Mr. Owen: In your Table VII, the total grams increase in iron which you gave at 195 includes the iron that came out in the initial out gallon of acid, and in the Table VIII the figure of 101.4 grams does not include that, is that correct? A. I would have to check on that. I believe that is the way it was done. As I said before, the concentration in the initial out, since it is only one gallon of acid, is a negligible amount, as a rule, and I wouldn't want to rely on that difference in the report here to indicate that that was the cause of the difference. It might account for a few grams, but it wouldn't be a major thing.

Q. Now, I wish you would in connection with Tables V, VI, VII and VIII do what you did in connection with Tables I, II, III and IV, that is, compute the loss, the

average loss of weight per 100 feet per hour of contact between the acid and the walls of the pipe? A. In Table V, run 1-B, the tubing lost 64.4 grams of iron per 100 foot of length per hour of contact. In run 2-B, the tubing lost 84.6 grams of iron per 100 foot length of tubing per hour, and the average of those two, 84.6 and 64.4 would be 149 over 2, which would be 74.5. Then in run 2-D the loss in weight was 59.3 grams of iron per 100 foot length of tubing per hour, and in run 2-E it was 29.4 grams of iron, and the average of those is 44.4. The average of the averages is 59.4.

Q. And the average of the average in connection with the first four runs is $264\frac{1}{4}$? A. Yes.

Q. Now, can you explain in some way the relative rates of corrosiveness indicated by those two sets of runs, the first four being without an addition of copper or lead, and the second four being with additions of those metals?

A. Well, if you take—

Mr. Lyon: I am going to object to that on the ground it includes the result of Table No. VIII, which is admittedly way out of line, because there was no initial sample taken, and the result almost 100 per cent below No. VII, which had the initial sample, and on the witness' statement, as it contains the same amount of copper, that it should have the same value, so where we are averaging figures in here that are admittedly wrong it should be excluded.

Mr. Owen: I object to the statement that the figures in Table VIII are admittedly wrong. The witness has explained that the figures in any one of these tables are not stated to be accurate to the last degree, and they were all made in the same way, the tests were made in the same way, and the analyses were made in the same way, as I understand it. A. That is correct.

The Court: Well, I will let it go in with your criticism of it. You may put that in.

A. Well, if we take the corrosiveness of the first four runs of commercial 15 per cent acid as $264\frac{1}{4}$ and the average of the last four runs with the added metals as 59.4,

Dr. Carl F. Prutton

why the commercial acid is 264 divided by 59, or the commercial acid is 4.46 times as corrosive as the synthetic acid. The average of these four—

The Court: Do I understand from the eight, however, there is omitted from that all that ran through in the first twenty minutes? A. That is not omitted.

The Court: You took these samples every twenty minutes? A. Yes, but the initial sample was taken in the first gallon that came through. The first single gallon that came through, and then the average sample was taken over that twenty minute period, and including even that first gallon.

The Court: One gallon? A. Yes. It is a very small amount and it has very little significance.

The Court: While it is high, in a gallon there couldn't be very much? A. Out of 180 gallons that we ran through.

Mr. Owen: Doctor, how much difference would there be in the figure you have given in your last answer if you omitted Table VIII entirely and took the average of Tables V, VI, and VII for the runs in which you added lead and copper?

Mr. Lyon: My point is, Your Honor, these averages seem to me have to be scrutinized very carefully, because when you average two tests that are almost 100 per cent apart, why you are taking quite a liberty with an average.

The Court: I recognize that.

A. If you take the average of the first three tests, omitting the test described in Table VIII, the average amount of iron dissolved was 69.1 grams per 100 foot length of tubing per hour of contact. That is compared with 59.4 grams loss if you take all four and average them, and the raw acid, or the 15 per cent acid, the number of times more corrosive than that is in the acid of the first three would be $264\frac{1}{4}$ divided by 69.1, which is 3.83, so it is 3.83 times as corrosive, so taking either the first three, or the four, and averaging them up, the corrosiveness of the raw 15 per cent acid is about four times as great as that of these acids to which the metals have been added.

Q. What was the size of your tubing you used in these

Dr. Carl F. Prutton

tests? A. The tubing that was used was standard inch and a quarter oil well tubing.

Mr. Lyon: May I ask you how much it weighed per foot? A. I think that is in the report. It is right on the first page of the report. Page 3, the first one and a quarter inch oil well tubing, external upset, range 1, 2.41 pounds per foot of length.

The Court: I don't know if I got an answer to my question. This bears the date June 20, 1941. Were all of these things done prior to that? A. Yes.

The Court: They were all done before that, and then you made up the report? A. Yes.

The Court: And shortly before? A. Yes.

The Court: I don't care about, as far as I am concerned, the exact date, but this date here is after you got through all of this. A. That is correct.

The Court: You tabulated this. A. Yes.

The Court: All right.

Mr. Owen: Now, I would like to offer the report as PX-184. The offer includes all of the other PX's which have been identified in the report.

The Court: Well, I will admit that. The entire report of June 20, 1941.

(Dr. Prutton's report of June 20, 1941, was thereupon marked PX-184.)

Mr. Owen: Doctor, what is the size of the tubing used in oil wells generally? A. Usually it is about two inches.

Q. Can you compute what the loss of iron would be in 1,000 feet of 2 inch oil well tubing, taking as the rate of loss the average of your first four tables, I, II, III and IV, which you gave as $264\frac{1}{4}$ grams from 100 feet of $1\frac{1}{4}$ inch tubing with contact between the acid and the tubing for one hour?

The Court: Just on the inside.

Mr. Owen: Just on the inside. A. Just on the inside. The inside area of 2 inch tubing for 1,000 feet is about 540 square feet. The inside area of inch and a quarter tubing, 1,000 feet long, is about 340 square feet. So if we multiply

Dr. Carl F. Prutton

264 $\frac{1}{4}$ by 10 we get the amount of iron that would be dissolved from 1,000 feet of inch and a quarter tubing in one hour, and then if we multiply that by the ratio of the area, inside area of the 2 inch tubing to the inside area of the 1 $\frac{1}{4}$ inch tubing, we would get the amount of iron that would be dissolved from 1,000 feet of 2 inch tubing, and if we do that the figure comes out to be about 4200 grams. 4200 grams of iron would be dissolved in one hour from 1,000 feet, the inside of 1,000 feet of 2 inch tubing.

Q. And that is about 9.3 pounds of iron would be dissolved in one hour, 4200 grams.

Mr. Lyon: Do you have what per cent of the weight of tubing that is? A. No, I do not.

Mr. Owen: Now, in what form would that iron go down into the well? A. Well, it goes down as a mixture of ferric chloride and ferrous chloride.

Q. What action would those ferric and ferrous chlorides have in the well if they got into the formation?

Mr. Lyon: Well, I object to that on the grounds there is no foundation laid. I mean he is not entitled to express an opinion unless he is qualified. He hasn't testified to any knowledge of oil well formations or any experience with them, or anything of the kind.

The Court: I will overrule the objection. A. A solution of acid containing an appreciable amount of ferrous chloride or ferric chloride contacting calcium carbonate, which is the main ingredient of limestone, the ferric chloride would precipitate as ferric hydroxide and there would be a tendency to plug up the pores of the formation due to that precipitation. The ferrous chloride would have some effect upon the viscosity of the solution, making it a little thicker if it were present, thus retarding its entrance into the formation. In forming the ferrous chloride some of the acid has been consumed, and therefore the acid concentration would not be as great as it should have been. That is, as great as 15%, which is the concentration usually forced into the top of the well.

Mr. Lyon: I don't understand that. How much did

Dr. Carl F. Prutton

you say the concentration was reduced in this particular instance that you are testifying to? From 15% to what? A. It would be reduced—I haven't figured that out. I can figure it out.

Mr. Lyon: I would like to know what you are testifying to. I would like to know whether that is a significant quantity or not. In this example you have given, how far would the concentration be reduced? From 15% to what? A. Well, this calculation wasn't made for the intent of showing any exact reduction, but if we take a typical oil well, which is usually a couple of thousand feet deep, and give some contacts of the acid of 15 hours instead of one hour—

Mr. Lyon (interposing): No, take two hours. A. We'll multiply 3 times 15, and we get 45 times as much corrosion.

Mr. Wiles: This is not cross examination.

The Court: This is so complicated, maybe you better wait. I am glad to have it, but I think there is some other little thing that is involved that you can bring up in cross examination.

Mr. Owen: Doctor, you have referred to tests you made in a tank, or placing acid in a tank which you have referred to as duplicating the Menaul tank. Will you explain what tests you made, how you proceeded. And in that connection, I believe you have a report. A. Yes, I have a report of the tests.

Mr. Owen: I will hand up a copy of this report to the court so the testimony will be followed and will give a copy to defendant counsel (handing same to court and counsel).

Q. I think first, Doctor, I will ask you to explain the construction of the tank which you made. A. We prepared a tank, a steel tank of 240 gallons capacity, duplicating as close as we could the important details of the construction of the Halliburton truck tanks from the information received from Mr. Rebbeck of The Dow Chemical Company. He supplied us with a drawing of the tank, a statement as to the material the tank was made of, a statement as to the

Dr. Carl F. Prutton

relative area of lead sheet in the bottom of the tank to the area of the inner surface of the truck tank, and as to the composition of the sheet lead used, as well as the methods of assembling the sheet lead into the steel tank. From those instructions we prepared a steel tank which is described in this report. The tank was 34 inches square by 50 inches tall.

Mr. Owen: May I interrupt just a minute. I think, Your Honor, I will have this report identified as PX-185, and then we can refer to pages.

The Court: We will call this whole report PX-185.

Q. Now, what page are you referring to? A. Page 3 is a description of the tank that we prepared.

Q. And where is that tank illustrated in the report? A. On page 14 there is a side view of the tank in position for the runs, page 14, or Figure 2.

Q. Page 14 is a photograph in my copy. A. That is a photograph of the tank. Figure 3 on page 15 shows a sketch of the tank and shows some of the details of fastening in of the lead sheet on the bottom.

Q. You might explain that. A. That figure 3 should be viewed in the other direction. If you hold the report on the side, the bottom of the tank is down here (indicating) and this upper edge with reinforcing rim is on the top. The tank was prepared from manufacturer's Grade A steel plate $\frac{1}{4}$ " thick and was fabricated for us by the J. T. Ryerson Company of Cleveland, Ohio. The tank was electro-welded. The inside of the tank was cleaned by sand blasting. And then a sheet of chemical grade lead was fastened inside the tank on the bottom. The sheet of lead was burned into a strip of steel, as described on page 3, on opposite sides of the lead sheet which was 33 inches square and $\frac{1}{8}$ inch thick, two strips of No. 10 blue annealed steel, three inches by 33 inches, were fastened to the edge of the lead sheet by burning.

The Court: What was fastened to the lead sheet? A. Two strips of No. 2 blue annealed steel. Just thin sheet steel.

Dr. Carl F. Prutton

Mr. Owen: Does that appear in that Figure 3? A. That is the heavy horizontal line.

Q. The steel is in an "L" shape, is it? A. The steel, as I recall, was in a flat sheet, and this figure isn't quite correct as I recall. I can find out in just a moment, if I could ask my assistant.

A Voice: It was "L" shaped. A. It was an "L" shaped piece. It was not just a flat strip. That is right.

The Court: The sheet right at the corner? A. The sheet right at the corner.

The Court: Extending up along the side and a little ways out on the bottom. A. The lead sheet was burned to the bottom part of that "L" and then the "L" of this blue annealed steel strip was welded onto the side of the tank at three points, in order to tack it onto the side of the tank. So the upper half of this strip at three points across there, the strip was welded onto the steel tank.

The Court: Does the lead extend up along the side at all? A. No.

The Court: The lead is just on the bottom? A. On the bottom, yes, and this "L" shaped strip of steel was burned to the lead, and it was spot welded onto the side of the tank in three places. Now, the tank, before use in these tests, was polarized, or that is the term used by the Halliburton Company for this operation. As stated in letters from Mr. Rebbeck, the Halliburton Company polarizes their truck tanks. They prepare the tanks.

Mr. Owen: Your Honor will recall, that was in Mr. Edwards deposition, which was read into the record.

The Court: Yes, I remember. A. They prepare the tanks when they are new with the steel and lead sheet assembly, and then they fill the tank with acid, and into the tank, the top of the tank, they insert a strip of sheet lead, and they connect that sheet lead with the positive pole of a lead storage battery, and they connect the tank with the negative pole of that storage battery, and they electrolyze the contents of the tank, and with the idea that after allowing the storage battery to become discharged by

Dr. Carl F. Prutton

standing all night and current passing through the acid in the tank, that the tank is polarized.

The Court: Polarizing, you mean a positive and negative, is that what you mean? A. Polarizing is a term that has a very vague meaning. That involves mostly any kind of effect that reduces the voltage of an electro-chemical cell. In other words, if you have a battery and something happens to it and your voltage goes down, then they say it is polarized, or if you are electro-plating and putting a voltage into the cell and the voltage goes out, they say it is polarized. In other words, it is a general term that indicates something has happened to disturb the voltage relationships in a cell. It is a vague term and covers many types of things. For example—

The Court: The north and south pole are the positive and negative, and the electricity does some vague and indefinite thing, that is what you are referring to by polarizing? A. Yes. It refers to that, but it primarily refers to the voltage of the cell. That is the more scientific definition.

The Court: It loses it all if it gets it? A. If it is a battery that is giving out energy, like a storage battery that you have in your automobile, anything that reduces your voltage is called polarization, because it is reducing the effectiveness of the battery, but if you have an electro-plating operation, that cell is absorbing energy from the generator. If something happens that increases your voltage, its efficiency is lowered, then they call that polarization. It is a very vague term and its use in this particular case is simply another name for lead plating the inside of a tank. That is all it is. It is just used in a loose sense. What happens is that the lead dissolves from the strip of lead which is put in the tank and plates out and covers the steel up more or less perfectly.

The Court: But you have got a steel plate in there that is the other pole? A. That is the other pole, and then the dissolving—

The Court: You don't rely on just the steel of the tank? A. No.

Dr. Carl F. Prutton

The Court: But when they say they polarize— A. They have the two poles, the lead strip and the iron tank, and the lead dissolves from this strip and plates out on the tank and coats over the steel.

The Court: Is that a strip of lead? A. This is a strip of iron that we fasten the lead sheet into the tank. This is the side of the tank. This lead sheet is down at the bottom. The strip comes up like this and it is fastened to the bottom, the lead sheet is in the bottom.

The Court: It doesn't cover the whole bottom? A. It covers the whole bottom.

The Court: The whole bottom is covered? A. Practically the whole bottom. When they prepare these tanks they have the lead sheet in the bottom. That will save it all the time, but they fill the tank up with acid and then they put another lead sheet in the center of this acid.

The Court: Down into it? A. Down into the center. Figure 4 shows this polarizing assembly. They put a lead sheet in there. They fill the tank with acid and put a lead sheet into it and then connect the lead sheet, this added lead sheet. That is taken and connected to the positive pole of a storage battery, but not while it is in use.

The Court: You say not while it is in use? It is while it is doing this polarizing? A. That is only done once. That is only done when they first put the tank in service, as I understand it.

Mr. Lyon: The tank is only polarized once?

The Court: Everywhere there is steel there is a tendency to do that. A. They plate lead on to it.

Mr. Lyon: In other words, you don't have to use your acid going into the well to accomplish that result. They do it in the beginning.

The Court: I guess it is a part of the building of the tank, if you want to think of it in that way.

Mr. Lyon: That is right. They lead plate the tank in the factory, or before they put it in service, otherwise they would have to be using the well operations in lead plating the tanks.

Dr. Carl F. Prutton

The Court: All right. But this is once in a lifetime?
A. Just in the beginning.

The Court: What it does is to put a lead coating on there? A. Partially.

The Court: And we can think of that as being done and that acid taken out? A. That acid is taken out and then the tank is ready for use.

The Court: All right.

Mr. Owen: Then this lead sheet which is suspended in the tank in Figure 4 is also removed? A. That lead sheet is removed and the lead sheet in the bottom stays in there.

The Court: That lead sheet is all over the bottom, as I understand it? A. Yes.

The Court: Will you agree to that?

Mr. Lyon: I think so, yes.

The Witness: The tank was 34 by 34 and the sheet was 33 by 33, so it substantially covers the whole bottom.

The Court: That explains where I got the idea it did not cover the whole bottom, but it pretty nearly does. You cover the whole bottom? A. 33 by 33 we used.

The Court: You followed the same proportion? A. Yes.

Mr. Lyon: I understand there is a man here that operates these tanks and he says these sheets do not cover the entire bottom, but they very nearly do.

The Court: That is what he did.

Mr. Lyon: There is a certain ratio of the area of the surface of the lead to the surface of the tank, which we will have to give you the formula for. A. We had to use that same ratio as close as could be calculated from the drawings of their tank.

The Court: Now, I haven't yet got—I understand the tank is a steel tank? A. Yes.

The Court: Now, you add the piece of steel, but I haven't got that through my head yet.

Mr. Owen: The only purpose of that is to hold the lead in place.

The Court: That is the only purpose? A. Yes.

Dr. Carl F. Prutton

Mr. Owen: It holds the lead in place and makes contact between the lead and the iron of the tank, electrical contact.

Mr. Wiles: That was explained in one of the depositions. They said it was too difficult to solder the lead inside the tank.

The Court: As to this plating operation, if they could have held it without anything it would have been plated just the same? A. Oh, yes.

The Court: It has no purpose, only as a holder? A. That is right.

The Court: And in making the holder they make it of steel? A. Yes.

Mr. Wiles: The lead could be just as well soldered or burned into the tank direct, only some man would have gotten inside, and it was a hard job to do it.

The Court: Well, all right. Now, I have got my tank straight.

Mr. Owen: And the sheet of steel at the bottom of the tank stayed there permanently? A. Well, the strips holding the lead stay there permanently.

Q. I mean the sheet of lead stayed there permanently in the bottom of the tank? A. Yes.

Q. And the suspended sheet of lead used during the polarization is removed after that operation? A. Is never used again.

The Court: Will you give me some idea how thick a coating that is, what that means, a little bit more, on that tank, that lead plating? A. It isn't very thick.

The Court: It is nothing I can see if I look at it? A. I think you could. If you wiped it, it would probably come off, partially.

The Court: Lead is soft so it will come off. A. It will not be any major thickness, I don't believe.

The Court: A thousandth of an inch? A. Might be a few thousandths. It isn't a continuous coating. Part of the lead plating never continuously plates over the steel, so there are little holes through it that the steel is somewhat

Dr. Carl F. Prutton

exposed, but there will be just some particles of lead covering most of the surface. The exact thickness of that would be difficult to say, but it is probably a few thousandths of an inch.

The Court: Maybe I am anticipating again, but are you going to account for anything that happens by this lead coat that is on there to start in with, is that going to enter into our problem? A. Not as a major factor.

The Court: All right. There is an awful lot of surface of that, if we are looking for a lead surface. A. That is correct.

Mr. Lyon: That enters into the protection of the tank, doesn't it? A. The protection of the tank.

The Court: But I am wondering if now, in this, they are going to now talk to me about and have been talking to me about the inhibition that comes from copper and lead, and I am wondering whether you are going to explain in any degree or take into account in any way that lead that is already plated onto the walls of this tank in connection with that other subject I have got to think about, which is the big subject, on infringement.

Mr. Lyon: The plaintiff here is talking about the action on the pipe down the well. The primary purpose or the real purpose of our lead, bonded lead in the tank, and the action in the tank, is to protect the tank. That is the real purpose of the Menaul system, is to protect the tank.

The Court: Yes.

Mr. Lyon: What it does down to the pipe is another thing.

The Court: What they claim is that your system puts inhibition into the solution.

Mr. Lyon: They say we get some copper in and that copper really protects—

The Court (interposing): And lead.

Mr. Lyon: But they say it is really the copper that does the protecting.

The Court: Yes.

Mr. Lyon: Down the well.

Dr. Carl F. Prutton

The Court: They give some credit to the lead.

Mr. Lyon: Yes. But as I understand the witness the lead is a minor factor. A. Well, it may be one-fifth, if there is copper or something like that.

The Court: Let's find out right now, before we get into this, whether there is any claim that this lead that is plated onto the walls of the transportation tank enters in in any way, that plated lead enters in in any way into the claim of inhibiting the acid.

Mr. Owen: Well, I think it does, Your Honor.

The Court: Well, all right then. That is what I want to know.

Mr. Owen: My understanding is that the acid placed in that tank after it has been polarized not only dissolves lead from the lead plates in the bottom but it also dissolves lead from the walls of the tank.

The Court: I want to know what to watch for.

Mr. Owen: And that both of those are sources for the lead which is found in the treating acid. That is your understanding, Dr. Prutton? A. I think some of it comes from the sides. It is so indefinite as to the amount I can't tell how much of it comes from the sides.

Mr. Lyon: I would like to state our position so the court may have it in mind. The purpose of our system is to protect the tank. They polarize the tank to get this lead plating on it to start with. But if they didn't have this lead in the tank bonded to the steel, that lead on the walls would come right off in a short time. And, therefore, they have to have this other lead plate in there, which continues to keep it.

The Court: As I understand it, wouldn't it continue it? A. Very slightly. It would continue to some extent.

The Court: And keep it from coming off, against the taking of it off?

Mr. Lyon: We will show Your Honor how long the steel tank would last even if we polarized it if we didn't have that lead plate bonded in there to keep up the polarizing action.

Dr. Carl F. Prutton

The Court: I guess I have it all in mind.

Mr. Owen: I would just like to read from the opening statement of counsel, which seems to me is not entirely consistent with what he has just stated that the only purpose of this lead plate so far is to protect the tank.

Mr. Lyon: I didn't say that.

Mr. Owen: This is what he said in the opening statement: "Now, as to our method of protecting our pipe, we don't add any chemical, don't add any arsenate, don't add any chemical at all. We have an electrical method of protecting the pipes. Certainly that raises an entirely different question of infringement than anything they had in the Williams case where the defendant was adding one of the very materials mentioned in plaintiff's patent. Here we have an electrical method and it is covered by our own patent."

Mr. Lyon: Now read the rest of it.

The Court: I don't understand the change from that.

Mr. Owen: That is the end of it.

Mr. Lyon: Oh, no, it isn't. I explained to the court that theoretically the electric current, on a theoretical basis, may aid in the protection of the pipe down in the well, but that that was theoretical and could not be demonstrated.

The Court: You continue the battery during the transportation?

Mr. Lyon: That is correct.

The Court: I don't see why the same operation, leaving the tank, wouldn't tend to continue to do it.

Mr. Wiles: Did you say he continued at all times the battery?

Mr. Lyon: We have the lead bonded to the tank and keep the battery action going while the acid is being shipped out to the well.

The Court: But you don't have an outside battery?

Mr. Lyon: Don't have any battery.

The Court: Pumping on it like you did when you plated?

Mr. Lyon: That is right.

Dr. Carl F. Prutton

The Court: All right.

Mr. Owen: We will go into that question further later in the case, Your Honor.

Mr. Owen: Now, doctor, will you state how you proceeded when you made a run through your pipe system utilizing this polarized tank? A. The set-up of the system that we used in these tests is shown on page 17 in this report, in Figure 5. We mounted the stoneware crock, which I have described before in the former tests, on the balcony of the large laboratory, and from the bottom of that crock we have Pyrex tubing that would lead the blended acids in the crock, and we had them at the correct composition, would lead them into this Menaul tank. You might conceive that this stoneware crock is something like a storage tank in the actual field operation of this Menaul process, that the acid is diluted and then dumped into the truck tank which corresponds to this steel tank of ours.

The Court: Now, your theory was you are getting acid in this stone crock as near as you could, as you understood it, like the acid when it was dumped into the transportation tank?

Mr. Owen: Yes, like the acid after it was placed in the transportation tank, and diluted to 15 per cent. We placed in this stoneware tank a 15 per cent solution of hydrochloric acid.

The Court: I had forgotten the water. So far as anything else that is in the acid other than the water to dilute, there was nothing else placed in it? A. Nothing else added, it was simply 15 per cent.

The Court: It was like it was and in other words commercial acid, as they say at that time? A. Yes, that is all. We added nothing in the tank except water to the commercial acid. The general method of the test was to dilute the commercial acid to 15 per cent concentration with tap water in the stoneware crock. Then after analysis and making certain that that acid was satisfactory to employ in the test by running the hydrochloric acid concentration and the corrosiveness of the acid as compared with C. P.

Dr. Carl F. Prutton

acid, that acid was then run into this Menaul type steel tank which had previously been polarized and washed out after polarizing.

The Court: That has got the lead in the bottom and it has got the plating lead plated as near as you can do it like the defendant's tank, transportation tank is lead plated when they get it in?

Mr. Owen: Yes, Your Honor.

The Court: The only difference in the whole thing is that they have their water in this tank and then let that run in, and you put the water in above?

Mr. Owen: That is right.

The Court: So instead of my saying when you dumped it in I will say right after you dumped it in you got just what you understand they have right after they put their acid in? A. That is correct.

The Court: Both as to tank and what is in the tank. I am ready to go. A. The acid was stored in this tank before it was dumped into the steel tank, and it was adjusted to 85 degrees Fahrenheit, and was kept at that temperature in the steel tank as well, so we are running at 85 degrees Fahrenheit, just as we did in the former runs.

The Court: Well, now, that is a little bit hotter than theirs will be, unless it was last week. Last week that would be a little bit too cold for them, probably. I am just thinking. I am trying to compare everything as I go along. They probably didn't have theirs 85, did they?

Mr. Conner: If Your Honor wants to compare those particular temperatures that Dr. Prutton is running, against the actual weather temperature in this state and in the county of Ogemaw for the days on which those wells were treated, if you say so I will get those for you next week.

The Court: That was the reason they took it?

Mr. Conner: I don't say that, but I merely state I have the weather reports for those days on which these wells were treated, August 2nd and 5th, which were very hot days, as I recall it, it was up in the 80's and 90's, and

September 10th was a very hot day and it was up in the 80's all of 1938.

Mr. Lyon: It is not a question of what the temperature is in the air.

The Court: This is hotter for some reason or other than I would expect to find if I put a thermometer into one of the tanks. A. Down in the well it gets hotter.

Mr. Owen: You take a steel tank and run it several hours in the country with the sun shining, it is much hotter than 85.

The Court: You couldn't get any temperature but what somebody could complain about it.

Mr. Lyon: Are they contending that there is some significance, some infringement here, because we acidized in the summer?

Mr. Owen: No, we say that you are infringing both summer and winter.

The Court: The doctor had to take some temperature and it is fair of him to tell us what he did take.

Mr. Lyon: The point is he maintained a particular temperature in this tank by using some heat, whereas the defendant, I don't think there is any dispute, does not add any heat to its tank.

Mr. Owen: No, we don't claim that.

Mr. Lyon: It is the temperature of his tank, it is whatever it will be because of atmospheric conditions.

The Court: If he hasn't taken it at all you probably will be saying you don't know the temperature. We can readjust from that. We know and I am glad we do, what temperature he has. A. I think 85 degrees Fahrenheit is very close to the bottom hole temperature of any wells in Michigan, and that was one reason for that.

The Court: I got an idea it was a lot hotter. A. I don't know. It is sort of an average temperature.

The Court: All he can tell us is what temperature he did use. A. This acid was run into the steel tank and agitated periodically with a glass, heavy glass rod for a period of six hours. Just stirred it every fifteen minutes with a

Dr. Carl F. Prutton

glass rod for a period of six hours, which we felt would duplicate in some manner the contact ~~time~~ and the amount of agitation that acid being transported in a Menaul type tank truck would get in being taken from a storage plant to the well.

The Court: And you are stirring it also as near as you could come to the agitation it would get by being hauled? A. I don't think it duplicates it.

Mr. Lyon: I think these roads are rougher than fifteen minutes stirring out in the oil field.

The Court: But they stop and stand. A. After standing in the tank, the acid standing in the tank, the contents of the tank was then siphoned through this tubing system that we have previously described. Now, we had to, in order to get it out of the tank without running it out of the bottom discharge in the tank, we had to siphon it, and shown above the tank is an arrow indicating a vacuum supply. We had a vacuum pump connected with that, and that vacuum pump went into a large Pyrex bottle, which is shown as a rectangle just directly above the steel tank, right at the top end.

Mr. Owen: Shown more clearly on page 18, Your Honor. A. That is correct. The vacuum was maintained in order to keep the piping system full of acid at all times. It was siphoned through the piping system, but to fill up the tubing to start the siphoning action we had to apply the vacuum at the beginning and fill the entire system up with acid, and then start the siphoning action, and we had to maintain that periodically, to apply the vacuum, in order to remove any hydrogen gas which was formed during the dissolving of the iron by the acid running through it. Hydrogen bubbles would accumulate which would break the siphon action, so the hydrogen was removed through this vacuum pump, and we maintained a level of acid up into the bottle at the level mark N on the bottle here, and in that manner maintained the siphoning action continuously, and the oil well tubing was always full of acid.

The acid was run through the tubing system at the rate

of ^{one} 100 gallons per minute, and adjusted as we have described previously. The two different types of tests were made, first tests which follow the teaching of defendant's Menaul patent, U. S. No. 2,149,617. We connected the wire from the truck tank or the Menaul type tank to the tubing system to make electrical connection between the two, and ran several tests in that manner following their patent. Then we ran also several tests in which we disconnected that wire to break the electrical circuit and prevent any electrical action, and the results of those tests are described in the tables that are contained in this report.

In Table IX, run 1-M, we used the Menaul type tank and the acid was in the tank in this case six hours and 33 minutes, agitation, and then the acid was run over through the tubing at the rate of one gallon per minute, using Series 1 tubing. The average analysis of the acid leaving the Menaul tank was 3—

The Court (interposing): That is at the end of the pipe? A. That is at the inlet of the pipe. That is this steel tank, duplicating the truck tank. That is the inlet.

The Court: When you started? A. When we started up in the stoneware crock, the acid contained substantially no lead or copper, and was substantially as corrosive as C. P. acid. Then we ran it into the tank truck and agitated it for six hours and picked up lead, copper and iron, and these are the concentrations of the acid we took with that simulated truck during the run, and we analyzed for the metal content of the acid run through the tubing.

The Court: Your thought being that this was the condition of it and the content of it as at the time it started into the tubing and you are trying to show by that what you think it would be at the time it started into the well. A. That is correct.

The Court: All right. I follow you. A. (continued): 362 parts per million of lead, 4.3 parts per million of copper, and the content of the iron varied considerably during the run, and we took a number of samples out of the Menaul type tank during the runs to get more—a better

Dr. Carl F. Prutton

picture of the iron content because the iron is an important element in determining the amount of iron dissolved from the tubing. And so you find under the heading of "Samples Taken at the Inlet," that means acid taken from the Menaul tank just before it went into the tubing system, after it has been in there this six and a third hours.

We took samples while it was running out of this tank into the tubing, so we would get a better picture of the metal concentration, the iron concentration of the inlet acid to the tubing.

The Court: Well, now that tends to show that it was getting more iron into it. A. It picked up iron during the run.

Mr. Lyon: The rate isn't reported here. Have you got the amount of iron you found? A. Oh, yes, it is over under the heading of "Samples Taken at Inlet." You see the iron content of the tank was varying during the run. It was picked up. The acid was still picking up some iron from the tank, so we took samples every twenty minutes.

Mr. Lyon: Wasn't the copper changing, too? A. We took several samples, but the copper did not show nearly the extent of change that the iron showed, and this figure is the average of samples, and I can give you the individual or the composites of several samples that were taken.

Mr. Lyon: Did the lead change, too? A. The lead changed somewhat, too. These are the averages.

Mr. Lyon: I would like to have, so we can study it over the week-end for these different tests where there are averages and you have given only one figure—there are averages of different samples, I wish you would let me have the individual data. A. I will get those.

The Court: I know it shows a quite rapidly increasing iron content. That means iron chloride? A. That is correct.

The Court: And that means, doesn't it, that it was eating off of the tank at that rate? A. Yes, sir.

The Court: Or, at that increasing rate. A. Yes, sir. You see the commercial acid when diluted, the 15%, had

Dr. Carl F. Prutton

from 5 to 10 parts per million of iron. We dumped them all in.

The Court: What is there that shows how much iron there was in this when it got into the transportation tank before it— (Witness interposing): I have all those figures. They are not on this sheet. It was very low, 5 to 10 parts per million. We received no acid that had over 5 to 10 parts per million of iron. In the six hours of agitation it picked up from 1100 to 1200 parts per million.

The Court: Then one of the arguments is it did not protect that tank? A. It didn't protect it a great deal. It undoubtedly protected it over a steel tank but there was considerable amount of action on the tank.

Mr. Lyon: Could you tell us, also, in this tank whether there was any lead and copper in the raw acid? A. The analyses of the raw acid, which I have for all of the runs, show just fractional parts per million of lead and copper; all raw acid, and the iron content was never over 10 parts per million of iron, and only fractional amounts of lead and copper.

Mr. Lyon: But there was some copper and lead in the raw acid? A. There was, yes.

(Witness continuing): This acid entering the system had an average composition of 350 parts per million of lead, 43 of copper, and then a variable amount of iron as the run progressed. We analyzed the samples of the exit acid, the composite samples, and determined their iron content. And in the same manner that we used in the former tests of calculating the increase in iron content of the acid going through the tubing.

The Court: Now, this is the bottom of the tank? A. The bottom, second column from the right.

The Court: Comparable to when it reaches the bottom of the well. A. Yes.

The Court: I am not saying anything about how active it is, but that is the purpose of it.

(Witness continuing): And from the difference in iron concentrations and the volumes that had passed through,

Dr. Carl F. Prutton

we calculated the amount of iron that would dissolve from the tubing; knowing the amount that was in the inlet acid and the amount in the exit acid, the increase in iron content came from the tubing and that amount in this test was 322 grams of iron was dissolved from the tubing.

The Court: I think I know what your explanation is but that initial one again? A. Was the first gallon.

The Court: I think I know what your explanation is, but give me again why that is the highest of them all. A. Because in cleaning the tubing out there is always a few particles of loose iron it is difficult to remove, and the acid loosens those up and the iron runs down in the first slug of acid; the first small amount contains a higher amount of iron, usually, than the rest of the acid. Now, it is not essential that that be the case. In other words, it comes out when we clean the tubing. As I said before, it is impossible to clean out 112 feet of tubing.

The Court: What was in there you didn't clean out was free iron. That wasn't iron ferrous chloride? A. It was free iron but in a very small particle form and by the time it got down to the end the acid had dissolved it. We never could detect any metallic iron in the exit acid.

The Court: What is your explanation as to why—why is it we find an increasing one following that? A. I don't know. In this particular case in this one 1106 at the beginning, possibly we had removed all that fine iron dust out of the sample tube and had done a particularly good job of cleaning, whereas in the other test maybe we hadn't done that and a small amount remained in there.

The Court: Now, you have two columns for the iron there. Now I get the same sort of results. Or am I too far into what you are explaining? I get the same sort of thing away over in the last column for the iron in the sample taken out. I find the original one is large, which I take it you explain in the same way as you did the other, and then I find it increasing again down there. A. It increases because the inlet acid is increasing in iron concentration. You see, the iron from the tank—

Dr. Carl F. Prutton

The Court (interposing): But this is increasing. Let me see if I am right or not. A. The first one is 370, between the first composite in and the first composite out. The next one is 217, and the next one 410.

The Court: It goes up and goes down and goes up. Have you any theory at all about that? A. I don't know how to explain it. I haven't any theory for it.

Mr. Wiles: Were those samples the same size? A. Substantially the same size.

Mr. Lyon: Your Honor has referred to that before. I would like to give you some assistance on that. Isn't it true that same action is usually found in corrosion of a hydrochloric acid on steel—that it goes in waves? Have you made any tests of that kind? A. No, but the question was asked me yesterday why the amount of iron dissolved was low at the beginning of the test and then it rose up and fell off. The reason in that case—I just happened to think overnight—could possibly be the tank acid was 85° F, the tubing was 72 because it is in a thermostatically controlled building, and when the first acid went through the tubing it wasn't quite up to the temperature so the rate of corrosion was kind of low. When the tubing got up to 85, the rate got up high and the lead and metals in the acid are doing their inhibiting action by forming a minute film of molecules of this stuff, and then tend to drop down as you went along.

Mr. Lyon: That might be a possible explanation but I don't think the witness advances it as necessarily the one. I think it is only fair to state, Your Honor, there is no point about it in this lawsuit and the witness evidently hasn't studied it, but wherever you study corrosive action of hydrochloric acid on steel it seems, for some reason (that has nothing to do with this lawsuit) to go in waves. It starts at one figure and either increases or decreases, and then goes the opposite way and does it in waves, for some reason. It has nothing to do with this lawsuit. But it seems to puzzle Your Honor, so I thought I would make that explanation.

The Court: Another thing, as to columns 5 and 7 I

Dr. Carl F. Prutton

should keep this in mind; shouldn't I, that in column 5 we are dealing with a solution that has remained right in that transportation tank. To use the metaphor here that you want me to use, all the while, you first take out some; now the action is going on with the rest while it stays in there, and the last it has had more opportunity to work on it and therefore I would expect a little increase along there if there was any action at all. Now I come over here to column 7 and I have an entirely different proposition and I mustn't apply that thought to it at all because that acid is going on down through and I have nothing to account to me at all as to why the first that goes the whole length of that pipe should have any greater change on it than the next that flows the whole length of the pipe. They are quite different, so far as that is concerned, column 5 and 7, isn't that right? A. They aren't a great deal different.

The Court: I mean in the first one, if I am drawing cider out of a barrel that is getting hard, and I only draw it at different intervals, the last I draw out ought to be harder than the first. A. Yes.

The Court: Now, I haven't any such theory I can apply to column 7 at all. I find nothing in that because it didn't take any longer for one part of it to flow from the top to the bottom than it did the other, you see? A. But in flowing through this pipe it is picking up iron and the thing we are noting here is that apparently the rate of picking up iron does vary during this run.

The Court: Yes. But I say you can't explain that on the theory (it may be a poor theory) that the longer it stayed in there the better chance it had to get iron. While in column 7 it wasn't in contact with the iron any longer than the last batch with the first, while in column 5 the last batch was in contact with the iron longer. A. But there are peculiar things happening in this pipe that are beyond my ability to explain to you.

Mr. Owen: Well, I made some figures here, Your Honor, that seem to me to be entirely consistent with the increase in the amount of iron in the inlet samples. That

Dr. Carl F. Prutton

is where it is going in, the fifth column. I take the second figure there of 1200 and I find that the outlet, the corresponding outlet samples increased 370 grams of iron, and the difference between the next two is 417, and the difference between the final sets is 410, so it seems to me that increase in the outlet column is accounted for almost entirely by the increase in the iron in the inlet column.

Mr. Lyon: No. A. The difference is closer than the figures I estimated. I made some mistakes in subtraction.

Mr. Owen: 370, 417 and 410.

Mr. Lyon: The court calls attention to the one above that and the fact there is a drop from the first one and then it starts going up and then it starts going down again. A. That has nothing to do with the test. That simply has to do with the cleanliness of the pipe at the start and the first gram or two of loose iron in this inlet. In the initial tank sample that first gram was taken directly out of the tank and therefore should be below the samples that were taken as existed in the tank, so 1106 should be lower than 1200.

Mr. Lyon: Why shouldn't there be the same difference at each one of these stages? A. It is, except the initial out.

Mr. Owen: And that has been explained several times.

Mr. Lyon: The first stage of comparison after that initial you say is 370, the next one is 417.

Mr. Owen: Yes.

Mr. Lyon: Why shouldn't they both be the same?

Mr. Owen: Your Honor, I think we ought to postpone the cross examination. We don't seem to be making any headway at all.

The Court: I agree with you.

Mr. Owen: Now, Doctor, this Table IX you say in column 2, "Mensual method acid and special tank." Will you explain what is the significance of the term Mensural method there? A. The Mensural method is as described in their patent, which involves the forming of a galvanic steel by electrically connecting the truck tank to the head of the well, or the tubing, and that method was employed here of electrically connecting the truck tank with the top of the tubing.

Dr. Carl F. Prutton

Mr. Owen: And that, I will state, is or was the defendant's practice, Your Honor, in the three wells from which samples were taken. They connected the truck tank to the oil well tubing by a copper cable, and their contents—

The Court (interposing): Any battery now mixed up with that?

Mr. Owen: No battery, no, except that this lead plate in the iron tank, and the acid as an electrolyte, in itself forms a galvanic cell. That is right, isn't it, Doctor? A. That is correct.

Mr. Owen: But there is no outside battery, no external electromotive force there.

The Court: Except as the tank itself, with the acid, forms it?

Mr. Owen: That is true. Now, explain your next table, Doctor, Table No. X, and at the outset explain the first statement "Menaul Method No Wire Connected." That means, does it not, that you duplicated the other test as closely as you could, but did not connect the wire in Table X test but you did connect it in Table IX. A. That is correct.

The Court: And IX and X you run just alike except for that, is that right? A. That is correct.

Mr. Owen: The purpose being to show, Your Honor, that there is nothing in this connection between the tank and the tubing.

The Court: I see. In this test, the acid was agitated for $6\frac{1}{4}$ hours in the tank. Series 1 tubing was used. The average analysis of the inlet acid was 158 parts per million of lead, and 3.25 parts per million of copper. That is considerably lower in lead than the sample before and somewhat lower in copper.

Mr. Lyon: About 25 per cent lower.

The Court: And agitated the same length of time and agitated in the same way? A. As closely as we could. And samples of acid from the steel tank were taken at 20 minute intervals, and the composite samples analyzed for iron. That is shown in the fifth column, the figures for iron

of inlet acid. In the seventh column are the figures for the exit acid from the tubing system, when the increase in iron content in acid due to the dissolving of iron from the tubing is figured, 330 grams of iron were dissolved by the acid. In other words, we got exactly the same results with or without the wire connected.

The Court: You have got intervening figures that are quite different, aren't they?

Mr. Lyon: And I call Your Honor's attention to the fact that there was only about half as much lead in the second sample as there was in the first, and 25 per cent less copper.

The Court: Less copper.

Mr. Lyon: Yes, 25 per cent less copper. A. I think it has been shown here that changing copper from 3 to 4 parts per million makes little difference.

The Court: But what I was wondering, how did you get so much less lead and one-fourth less copper if you took the same acid? A. Yes, the same original acid.

The Court: I am wondering and I was carrying the thought that there hadn't anything at all happened up to the point of starting that could be different. You took the same crock. A. That is true.

The Court: You took the same acid and everything. Why do we start away from scratch with such different figures? A. Agitating by hand is a very variable procedure, Your Honor.

Mr. Owen: Which run was made first, Table IX or Table X? A. The first Table IX was run first.

Q. Well, might not the larger amount of lead and copper in the Table IX run as compared with them in Table X run be accounted for by the fact that the first batch of acid you put in that tank ate off the lead from the walls of the tank? A. That is the explanation.

The Court: But I thought that was when it went into the tank? This is before it has had time to eat. A. It is after it has been six hours in the tank.

The Court: This is? A. That is the acid before it goes into the tubing.

Dr. Carl F. Prutton

The Court: This 352? A. 362.

The Court: You did have them just alike when they went in? A. No.

Mr. Owen: When they went in the steel tank, they were just alike. •

The Court: That is what I mean. A. You have four runs that we made in this tank, a steel tank. It was polarized once, and the first run made in it, the lead was 362 after standing. The second run that was made in it the lead was given at Table XI, and it is 291, so it follows—

The Court: Which is the second now? A. The second run in chronological order is XI, which is 291, so it fell from 362 to 291. Then the third run is this one that we have here, and the fourth run is in Table XII, so—

Mr. Lyon: Were there any intervening runs? A. There were no intervening runs.

Mr. Lyon: These are the only runs you made? A. Yes.

The Court: Table XII is the fourth one? I will see if I get it in series at all. 362 and 291 and 168, is that it, and then 247? It jumped back up again. A. It jumped back up again.

The Court: I was wondering that would go down so I could have some theory? A. Taking a tank and agitating by hand is quite a variable thing, and it can vary 25 per cent, and that particularly applies to the lead concentration, and it is more difficult to dissolve in solution, just as we had trouble in dissolving lead chloride, and it depends on the agitation you get.

The Court: I don't know. I better follow that one. The first one was high because it was so—because it was the first, and there was more lead coated on? A. On the side of the tank.

The Court: Because my fourth one jumps way back up, which had from that standpoint the poorest chance of all. It was the furthest away from the battery plating of the wall, isn't that right? A. That is true. There is a considerable variation that you will get in lead content.

The Court: A witness when he performs his experi-

Dr. Carl F. Prutton

ment, he gets something he can't explain or I can't. I am glad to have you bring it to me just as you get it. Give me those in their order. A. 362, 291, 158, and 247, I believe.

Mr. Lyon: Now, Your Honor, I suggest you get the order of the copper contents too in the same arrangement, see how they vary. You have been looking at the lead. Why not look at the copper?

The Court: Well, all right. Give me those, Doctor. A. The first one is 4.3, then 2.88, 3.25 and 2.32.

Mr. Owen: Now, Doctor, will you explain, or had you finished with your explanation of Table X?

The Court: Go ahead. I will tell you all I haven't any theory, and I am waiting for you to give me one. A. Yes, I think I have completed Table X, in which we got substantially the same result as we had with the wire disconnected as we got with the wire connected.

The Court: When you got over to the final result they come out surprisingly close!- A. That is right.

The Court: But they travel quite different roads to get there, as I see it? A. Yes.

Mr. Lyon: That is why I am objecting to these averages.

The Court: Well, all right.

Mr. Owen: Take up Table XI now, Doctor. A. In Table XI the run number is 2-M, and this again is the practicing of the Menaul process, with the wire connected between the tank and the oil well tubing system. The same temperature and rate of flow of acid was used.

Q. The same series of tubing? A. The acid was in the special tank for seven hours in this particular case, and series 2 tubing was used. The average analysis of the acid in the tank was 291 parts per million of lead and 2.88 parts per million of copper. In column 5, under samples taken at the inlet in parts per million of iron are given the iron concentrations of the acid in the steel tank at various times during the run. In column No. 7, under samples taken in the acid in parts per million of iron in the exit acid are

Dr. Carl F. Prutton

given the figures, the concentrations in parts per million of iron, and the acid leaving the tubing system at various times during the run. Calculating the increase in iron content in the exit acid over the inlet acid is $265\frac{1}{2}$ grams of iron dissolved from the tubing.

Table XII, run 2-N is described. A Menaul method tank was used. The acid was placed in the tank for 6 hours and 30 minutes. The temperature was 85, the rate of flow was a gallon per minute, as before, but the wire was disconnected. Series 2 tubing was used. In other words, the same tubing as was used in 2-M, described in Table XI. The average analysis of the inlet acid was 247 parts per million of lead, 2.3 parts per million of copper.

The acid leaving the system,—the inlet acid in the storage tanks, in the steel Menaul tank was analyzed at various times during the run, and those figures are given in column 5, under samples taken at inlet, parts per million of iron. In column 7 are given the parts per million of iron in the exit acid leaving the tubing. From the increase in iron content of the acid and the volumes passed through, we calculated the amount of iron dissolved from the tubing, and it is 195.7 grams. In other words, it is somewhat less corrosive in this particular test with the wire disconnected than it was in the test 2-M where the wire was connected.

The Court: Do you attribute it to the disconnected wire? A. No, I attribute it to the possible variations in our test conditions. I don't believe it makes any difference whatsoever. I think the result should be the same.

The Court: There is a substantial difference though? A. 265 to 195 is 70 grams difference.

The Court: That is put in millions? A. That is grams of total iron dissolved, 265 grams of total iron dissolved. I don't believe the wire makes any difference, and that these tests would indicate that there was any appreciable difference. The first two comparative tests indicate the same result and the last two indicate the disconnecting of the wire gave somewhat lower corrosion. The main purpose of the test was to show that the wire doesn't materially change,—

Dr. Carl F. Prutton

decrease the rate of corrosion by connecting that wire, which is necessary to practice the Menaul patent.

The Court: There is a difference of 36, isn't there?

A. Yes, a difference of about 70 grams of iron.

The Court: That is quite a difference. Isn't that a large amount? I don't know. A. When you take raw acid and run it through this tubing we dissolve 1000 grams of iron, and here we have a difference of 70 grams.

The Court: One would indicate 70 per cent less harm than the other, or 30 per cent less harm than the other. A. I would be willing to concede the disconnecting of the wire actually improved conditions. I would be willing to consider that.

Mr. Lyon: We are not talking about that. Tell him how much inhibition it decreased by disconnecting the wires, or per cent, as compared with the wire connected, in what per cent have you reduced corrosion, on your own figures? A. We have reduced the inhibition of the acid by disconnecting the wire.

Mr. Lyon: By how much per cent? A. By 7 per cent, approximately.

The Court: More than that?

Mr. Lyon: Sure it is more than that.

The Court: You have 265—

(Witness interposing): No, I stated it in the opposite from the way you stated. I stated the reduction in corrosiveness or the inhibition in coming from 1000 grams down to 265, there is 750 grams of iron difference; if we reduce it to 195 there is only another 70.

The Court: You reduced it more than before.

Mr. Lyon: That is right. A. In corrosiveness. I said inhibition—

The Court (interposing): But say you have reduced the corrosion more than 25% by this. You don't claim it did, I don't claim it did.

Mr. Wiles: When you have it pretty well inhibited, for instance a 99% inhibition, and raise it to 99½, it is true there is a difference 50% in corrosion but practically you have no corrosion in either case.

Dr. Carl F. Prutton

The Court: All right. But you have reduced the amount of corrosion by more than 25%.

Mr. Wiles: That is true, but you have started out by reducing it down to a very small amount in the beginning.

The Court: Sure.

Mr. Owen: Your Honor, in considering this particular question you should go back to the tests made from the stoneware crock with uninhibited commercial acid. Those showed in Table I a total grams increase in iron of 1043.

The Court: I follow you that you say neither one of these are corrosive enough to do any harm. That must be the contention.

Mr. Wiles: They are very greatly improved in that respect.

Mr. Owen: They will do some harm, they are not perfect.

The Court: Then when it was disconnected it did change it more than 25%?

Mr. Owen: I don't know whether the doctor has any theory as to why there was less corrosion with the wire disconnected than there was with it.

Q. If you have a theory, I would like to hear it. A. The theory of electrolytic protection by galvanic action is interesting from a theoretical standpoint of connecting a metal which will dissolve more readily than iron to the iron and many people have tried to apply that in actual cases and have found that instead of getting inhibition they get the reverse. They get more corrosion when they connect things together like that, and particularly if they try to impress potentials upon a metal. I don't know whether this would be an instance of that case or not. As far as I am concerned, I would be willing to say both on the results of these tests and from my theoretical knowledge, that this connecting or disconnecting the wire would have absolutely no difference—it would be a small amount on the inhibition.

The Court: I get this from what you say. You performed many experiments before you reached the conclusion this connection of the wire was the cause of the

Dr. Carl F. Prutton

change? A. Yes, I wouldn't expect it to be of very great difference one way than the other.

The Court: I say you performed a good many experiments before you reached a conclusion. A. The results of these tests indicate to me substantially there is no inhibition produced by that wire connection.

The Court: Of course that is the danger. I agree fully with the explanation that that was less destructive—the acid was to iron, when it was disconnected than it was before; I wouldn't want to reach that on just one experiment. And I understand you clearly to say you don't reach that conclusion on one experiment. A. No, these experiments should be considered with the tests that I ran before. In describing those tests I mentioned that the first two tests I duplicated the composition of the acid in the steel tank and ran it directly from the stoneware crock to the tubing system; not only disconnecting the wire, not even having the lead plate in there in those tests we got exactly the same results with the wire connected or disconnected. In other words, six different series of tests, all duplicating, all pointing to the fact that the lead plate, the wire, the tank, has no effect on inhibiting corrosion in an oil well, and that also agrees with all theoretical principles of electro-chemistry.

Mr. Owen: Doctor, while we are on this subject, I would like to have your theory of the Menaul proposition that the pipe can be protected from corrosion by connecting up the tank to the pipe by this cable. A. The theory, as I explained it, in agreement with these tests, as to why the tubing is protected when they practice the Menaul patent is simply due to these metals which are added in the acid and which are fed the acid containing those metals, fed into the tubing. That accounts completely for the inhibition. The placing of a lead plate in a steel tank at a position electrically remote from the bottom of the well, or even inside the tubing, from a consideration of electrical circuits is that you might get some little inhibition on the end of the pipe that is sticking into the tank, but in any

Dr. Carl F. Prutton

circuit the electrical current takes the easiest path that it can to go through the circuit. It doesn't go through all the way to the bottom of a 2000 foot well, jump to the pipe and run back. If you have an electrical circuit and have two resistances connected between two bus bars, one resistance has a very high resistance, the other very low; all the current goes through practically the low resistance. There is no reason as to why the current should go down the acid through the tubing, to the bottom, jump across the tubing, back through the tubing, back to the tank as described in defendant's patent, and in that way protect the tubing.

Q. I wish you would trace that circuit as described in the Menaul patent down into the well and then back to the tank. A. They do describe in the patent one method of operation which would have some remote change of working, but which is so impractical that I don't believe it was ever even tried out, and that is to lower a lead wire down to the bottom of the well, keeping it from touching the sides of the tubing, and pouring acid down between the lead wire and the tubing. Under those conditions, you might get a little bit of inhibiting effect. But with the lead plate back in the tank and the circuit that you have to follow—if I may draw on the board here, I would like to draw it.

We simply draw a vertical tube in the ground, that you can visualize as being a couple of inches in diameter and several thousand feet in length, and that tube is full of acid. Then we connect that into a truck tank, and here is the truck tank, in some shape or other. In the bottom of this tank is this lead sheet and more or less lead covering the sides. The iron is partly exposed. There is definitely a tendency, a potential, which would make the lead negative as compared to the iron tubing, and a galvanic cell which you might figure would take some lead and plate it upon the iron. Now, between the tank and the head of the tubing there is a copper wire connected. Steel to steel, the tubing and tank. We have a circuit.

The Court: Each filled with hydrochloric acid. A. That is true. This is all acid. Now, we have a cell in which

Dr. Carl F. Prutton.

this is one electrode, the electrolyte or solution in the cell between the electrodes is hydrochloric acid, and this whole system is another electrode. The whole system is one electrode. Now, the passage of current between two electrodes in a cell, the current goes in the most direct manner it can. Now, the actual voltage of this cell, as will be shown possibly by the defendant, or we may bring it out, is on the order of a few hundredths of a volt.

Mr. Owen: I may read from some of the defendant's literature where they stated the voltage of the battery formed between the electrodes is ".35 of a volt. Therefore it should be a good conductor and as little resistance as possible in the short circuit so that this low voltage current can readily flow from one point to the other."

The Court: Now, this copper wire across there just hitches two irons together. A. Two metal plates together, and in between you have acid.

The Court: How is it any different than as though here you had a tank over there, and the pipe coming right immediately connecting to it? In other words, are all of you—I don't know, maybe—are any of you claiming that that makes it different than as though this was steel across the top and that just fitted right to it and came right around and it was all steel and all filled with acid around here? Does the fact that that is an open space there and this has copper across, does that make it different? A. It makes some little difference, but not appreciable. It is the same as you have in any type of battery where you have one electrode, like a carbon rod in an ordinary dry cell, that is the one electrode in the cell, that is the solid conductor, and then the other electrode in the dry cell is zinc. In between you have a thick solution of ammonium chloride. That is a typical battery. And you don't get that battery to function unless you connect it electrically outside. In other words, the dry cell just stays without acting until you touch a wire across here, or put a flash-light bulb across here, and then the current flows and then these actions take place. You have a complete circuit here with electrical current flow-

Dr. Carl F. Prutton

ing through the cell. And the light lights up. Now, the same thing is true here. If we have that disconnected, and the other connection, if we had this welded across here, we would have the same sort of condition.

The Court: That is what I thought. A. And the passage of current between.

The Court: Here you had your typical one, and you point out to me that you have one zinc and the other— A. (interposing): Carbon. One zinc in the dry cell.

The Court: Carbon and zinc here. A. Where we have this.

The Court: Lead is plating on one of them. A. Yes.

The Court: And to the other. A. The iron of the pipe, the tubing, is the other, all the way down the well. Now, the current flowing between these two electrodes passes through the path that has the least electrical resistance; it takes the easiest path out. It has to go through the acid, and, therefore, it has to go through the acid to the pipe, from the pipe back through the electrical wire and back around in this sort of a circuit, but if here the current went around in this direction and completed the circuit with this outside wire, we have a complete circuit.

The Court: You haven't got that hitting the lead at all. You have got to have that current go to the lead. A. I assume this was coated with lead. So the current comes from here, to here, back through the wire and back to here. There is absolutely no reason why it should take a path and run through the column containing solution for three thousand feet of a very low, poor conducting solution, three thousand feet, jump to the side of the tubing down here, and then run back through this pipe.

Mr. Lyon: Well, just assume that the entire side of the tank is coated with lead, and go ahead with your proposition. A. The inside of the tank?

Mr. Lyon: You can't have current flowing from lead to lead. A. You have exactly the same condition.

Mr. Lyon: You can't have current flowing from lead to lead. The current will flow to the nearest iron. A. If

Dr. Carl F. Prutton

this tank is completely coated with lead, as you state, and as I believe is your contention here—

Mr. Lyon (interposing): Yes. A. Substantially so.

Mr. Lyon: It is completely covered. A. It is completely covered. There is no iron exposed in the tank.

Mr. Lyon: You can't flow the current from the lead plate to the lead covered wall. A. There is substantially no current flowing from the lead plate to the lead covered wall.

Mr. Lyon: The current will try to flow from the lead plate to the nearest uncovered iron. A. I have exactly said that. It would flow from the lead across here. I consider this whole tank a piece of lead, because this is substantially coated with lead. That is all lead. Now, the current flows from this lead inside the tank to this tubing. But it flows through the shortest path of acid it can flow through, because it doesn't want to go through a long path of acid.

The Court: That sounds reasonable. A. Therefore, it doesn't go down to the bottom.

The Court: As I understand it, he is asking you to assume that that is all coated. A. That is all lead.

The Court: All right. Where will it go to? A. It goes from the inside of this tank, any place from the lead on the inside—

The Court: That is all lead. A. That is all lead.

The Court: Now, where? A. It goes to the end of the tubing.

Mr. Lyon: When that gets covered with lead, what happens?

The Court: That is what they (defendant) will claim, I suppose. They haven't said that, but I take it the theory is—and I want you to knock it out if it ought to be—I take it their theory is that that will go to the end of the tubing and it will coat that, and then it will go to the next nearest and then the next and the next.

Mr. Lyon: That is right. Theoretically, that is the basis of the engineers' reports on this.

The Court: And I think—they don't claim that it

Dr. Carl F. Prutton

would, while that is all open, run the whole length of the gamut and coat it all through.

Mr. Lyon (interposing): No. A. It would have to eventually run the whole length of it and do that plating at some time, by their contention. It is not possible to take a metal, a pure metal, suppose we take pure lead, and put it into a solution—let's take hydrochloric acid—and not take any other kind of an electrode over here, it is not possible for that lead to dissolve itself and then also to plate itself out in a continuous sheet on the other electrode without adding some voltage externally, no more than you can lift yourself by your boot-straps. The energy that this lead gives off in dissolving is required, and an even greater amount of current is required to plate lead from this pole onto this other electrode. It hasn't enough kick to plate a complete film of lead on this surface. So there is possibly a molecule here and there, scattered around. There is some very slight amount of plating, but you get that same kind of plating when you immerse iron in a solution of a lead salt.

The Court: The thing you are meeting—you don't have to meet the claim that it would start some plating down at the end immediately, down at the bottom immediately when you started, as I understand, because that isn't what they claim. But they do claim, and what you are meeting, is that it would not have enough energy left to even plate the tank, so it would never get through plating the tank? A. That is why they put the battery in, to get the plating on the tank.

The Court: And you claim they don't get sufficient—am I stating your theory and contention correctly about this, that it never does get far enough along so that it even gets the tank, out of which it is flowing, plated, and therefore it never begins to plate the pipe? A. It partially—this voltage or potential energy the lead has contained in dissolving is used and there is a slight tendency to plate out lead on this coating, but the amount of lead plated out is an atom here and an atom there, and very imperfectly cov-

ering it. In order to get a complete covering, they want to use a six volt battery, and you must remember we are talking about voltages on the order of a few hundredths of a volt here. And when they want a complete coating to protect their tank, they connect it to a six volt battery to help out the lead solution. If you take an ordinary lead solution, or a lead salt, and immerse iron in that, some of the lead will deposit on the iron. A very minute amount. If you put a few hundredths of a volt on, you get maybe a few more atoms of lead on. But to get a complete sheet of lead plating on a surface, you have to place some external voltage on it to do that.

The Court: It is my understanding that you say that in this weak battery it will never, the lead will never so completely cover the steel walls of the tank, and the little end of the tubing that stands down into it, so that there will ever be any current passing on the well side of the point where the copper wire is connected to the tubing? And it will always turn towards the tank side of it and go round and round in that side and that it will never, the tubing, get coated down beyond with lead, beyond the connection to the copper wire in such a way that the current will turn towards the well, and so down the tubing and then come back through the solution? A. The amount of any current that flows down here is substantially negligible. We have actual measurements of the current that flowed through this wire in our test, and it is in the order of millionths of an ampere that flowed, even here, and to express how much it plated down.

Mr. Lyon: What order of current density is required to plate lead on steel, what order of current density? It is in the order of a millionth of an ampere, isn't it? A. Current density has nothing to do with it.

Mr. Lyon: You made a measurement of this current and it is only a millionth of an ampere. That is all the current that is required to plate lead on steel, isn't it? A. There is quite a bit of information in the literature on the electrolytic protection of pipe lines, and this is an electrolytic protection.

Mr. Lyon: Can you answer that question? A. I don't have any information. I am telling you for electrolytic protection practiced commercially on pipe lines the current required is tremendously greater than a millionth of an ampere.

Mr. Lyon: Do you know whether or not current in a millionth of an ampere is sufficient to plate lead on steel? A. I can't tell you that, because the quantity of electricity flowing determines the amount of deposition of hydrogen and lead, which are two things that are simultaneously deposited and the conditions that you would have would vary greatly, and I don't think it would be possible to measure it, unless you measured a tremendous number of tests, and it is so far below any commercial figures given for electrolytic protection. Then it violates the deposition of electrical circuits, and also the tests that I have run here quite definitely prove that its electrolytic protection is absolutely of no value.

Mr. Lyon: I am trying to get you to tell us whether in accordance with your theory that there was no appreciable continuous plating in the defendant's tanks due to the presence of that bonded lead plate, if it would make any difference in the life of the tank whether or not the bond between the lead plate and steel wall was broken? A. I have said that you get some electrolytic protection in that tank, I believe. I have no tests to indicate otherwise, but I believe, and it is entirely reasonable that you would get some protection, that this lead would definitely have a potential which would tend to put molecules around on the surface and exert some little protection. Just how much I can't tell you, but to get thorough protection apparently you have to go to very high voltage, an added voltage, which will coat the surface over, practically continuously with lead.

The Court: I understand you, Doctor, to say that whatever the conclusion may be about protection given to that tank, if I go in there 5000 feet there is absolutely no electric current resulting from that lead? A. That is my contention.

The Court: Now, then, I have got the idea that you say that for practical purposes there isn't any of the other side, copper wire connection on the well side that the current starts from, where the copper wire connects to the tubing, and makes its way back through the solution on the tank side? A. The positive flow of the current is in the direction through the walls of the steel tank, through the lead coating on the inside, across the acid and it comes to the closest point on this metal tubing that it can, the current passes through there, and then back around in that direction, any current.

The Court: It never goes any further towards the well than where the copper wire connects with the tube?

Mr. Lyon: I would like to correct that. In your explanation it wouldn't make any difference where the copper wire from the tank was attached to the pipe. That hasn't anything to do with it? A. That has very little effect.

The Court: But you haven't any of you gotten what is bothering me. I understand the doctor to say that wherever you attach it, and I agree it doesn't make any difference, but that when it comes in contact with that tubing that it never goes any further towards the hole in the well, but its course leads back now into the tank? A. That is the main circuit, and the amount of current that would flow—there would be very little current that would flow, very little.

The Court: Now, how far, that is what I am getting at? A. It wouldn't flow, in my opinion, any distance at all, and the amount is so negligible—

The Court: In feet how far? A. I couldn't tell you. You can't calculate it.

The Court: You know it wouldn't be 5000 feet?

Mr. Lyon: You don't know that. A. It is my opinion it wouldn't go twenty feet.

The Court: Well, now, that is what I wanted to get at. A. That is my opinion. I can't prove it, but that is my opinion.

Dr. Carl F. Prutton

The Court: You could pull one of these things out some day more than twenty feet.

Mr. Lyon: He said that was his opinion and he couldn't prove it.

The Court: I know it. Maybe you can disprove it.

Mr. Lyon: I am not claiming I can. A. We haven't any proofs on that, I mean in the small set-up we made with our tubing system connecting the wire, we found where the tube,—where the wire was connected was inhibited. We had 112 feet in this tube system that we have and we measured the loss in weight of each length of tubing, and even the length where the copper wire was connected wasn't inhibited, so I say the amount of current that flows is not enough to do any good. The fact you can break this steel completely and take this whole thing away and get exactly the same amount of iron dissolved all is evidence.

The Court: It is my understanding of your testimony that the underlying reason for that is that it is your belief and opinion that this iron in the tank, not to exceed twenty feet of the end of the tube, never gets enough coated with lead, so by what it has all got, it has got enough iron to satisfy its appetite right there? A. That is right.

The Court: Isn't that the meat of it all? A. That is right.

The Court: And their contention, evidently, from this, because I feel so right about it, is the fact you wouldn't start at the bottom of the well, if there wasn't any necessity for it,—you don't take a great big detour unless the road is bad straight ahead, but their contention, as I understand it, is that they have got a tank that is coated so much it doesn't satisfy its hunger for that, and begins at the end of the tubing and rapidly goes down coating the tubing and in that way protects it.

Mr. Lyon: May I state the proposition? Our proposition is that we use this Menaul method to protect our tanks.

The Court: Yes.

Mr. Lyon: Our theory considers there is a good possibility that it may do some protecting of the pipe, but it is

Dr. Carl F. Prutton

purely theoretical whether it does or not, and there is no way in the world of establishing it one way or the other.

The Court: As long as they claim their purpose is to coat their tank, that is what they say, that is, that is what they say their purpose is, and it does give protection to it?

Mr. Lyon: We will prove that.

The Court: I will ask the witness right now, what do you think about that? A. Does it give protection to the tank?

The Court: Yes. A. It gives a slight amount.

Mr. Lyon: You don't know if it is more than that? A. I don't know. We have run tests in the laboratory against steel and it might inhibit the corrosion 30 to 50%, or something like that. It would vary with the conditions. Then you plated this battery to get more lead on this and that—

The Court (interposing): I haven't a very big dispute about this thing.

Mr. Wiles: The tank hasn't anything to do with the lawsuit any way.

Mr. Lyon: I think it has this much to do, Your Honor. Somebody said our use of this method was a smart trick in order to do something down the well.

Mr. Wiles: I say it is.

Mr. Lyon: That isn't the purpose of it at all. It is to protect the tank.

Mr. Owen: I would like to have the witness retrace that circuit in the defendant's tank when it is connected up with the oil well tubing by the copper cable. In tracing the circuit, Doctor, although you are illustrating it on the black-board, please make your description perfectly clear so that when read from the record it will be understandable? A. The tubing which may be simply dipped into the tank, or which may be connected through some pumping arrangement at the bottom of the tank, is electrically connected by means of a cable at the side of the truck tank; and, therefore, we will show here a copper cable connecting the oil well tubing to the outside of the steel tank.

Now, this steel truck tank has on its bottom a thick

Dr. Carl F. Prutton

sheet of lead, which is connected to the tank, and then due to their preparation of the tank by their so-called polarizing method, they put on a thin coating of lead on the side of the tank, and so we have a steel tank with the bottom practically covered with a heavy sheet of lead, and the inside of the walls of the tank partially covered with electroplated lead.

In the tank we have our hydrochloric acid for the acid treatment. Now, we will assume that this tube is full of the fifteen per cent hydrochloric acid, which it would be in case we were transferring it, possibly, through a pump or some other means from the tank down into the well.

The Court: Now, I am thinking of that, and see if I am wrong, I am thinking of this as one continuous body of hydrochloric acid. A. That is correct.

The Court: I am thinking of the steel as one continuous body of steel, and I am ignoring the copper wire. That is simply a little bit better conductor stuck in there, and I am thinking of this as this odd shaped thing running down there and all of that, but I am thinking of this as a solid bit of steel with all that connected across there, of course. A. That is right.

The Court: Just as if the steel ran across. And one big spot of lead down here in this, and the sparsely settled lead sticking up there. A. That is correct.

The Court: That is the idea I am carrying about that outfit. A. That is exactly correct. And if you imagine that down this well you are about one to three or five thousand feet away from this lead plate, so that this end of the steel tube in this example would be several thousand feet away from here. Now, the operation of this cell is that the lead goes into solution and current passes from the lead into the solution. Tries to get to the iron. It will go to the iron that is closest to it.

The Court: I would think so. A. In other words, the current from this lead would go to this iron. In order to protect down below here, the current has to pass from this lead sheet, up through the pipe, through the acid, always in

the acid, down through this column of acid, then come to the wall of the pipe and to its protection and then back through the wall of the pipe, back through the copper wire, back into the tank, to the lead plate.

The Court: Yes. A. In other words, in this example, which is a simplified diagram, the current goes from the lead into the solution and then travels in varying amounts to the iron surface closest to it, or to the iron surface three or four thousand feet away from it.

My contention is that the amount of current that passes from this lead electrode or sheet to a point a thousand feet away is substantially zero, since we have measured the amount of current that passes between this whole tubing system, the entire tubing system and the tank which we had in the laboratory, and the amount of current was on the order of a few millionths of an ampere, particularly in that the resistance of this hydrochloric acid is considerably greater than the resistance of the metals, and therefore there is absolutely no reason why current will take the hardest way to go any place. That is simply a law of nature. It would take a long while, and a fairly appreciable amount of current at least something greater than the order of a few millionths of an ampere to cover a thousand square feet of surface with any protective coating into the well.

As a result of the tests which we have run, when we broke that circuit, which prevents that action, when we broke that we got a little better action than we had with the wire in there.

And as I told you before in this applied electrolytic protection, there are just as many examples where electrolytics work in a negative manner than in protecting the metallic surfaces, and therefore the statement that I would make from our tests is that the wire had little effect, the electrolytic protection had little effect one way or the other, and I think that is what I stated last Saturday. And then the other argument, the difference in potential that existed between this tank and the tube in our set-up was down in the order of one or two hundredths of a volt. The difference

between this lead plating side of the tank is a little greater than that, I will admit, but the potential difference is so slight that any protective action that you would get, the tendency to plate lead out is negligible, because that plating out requires a different potential. In the surface of ordinary steel pipe differences in potential occur between different parts of the pipe. That is, if you take a piece of pipe and expose it to hydrochloric acid, or any water solution, differences in potential between particles of the steel and the iron crystals of the ferrite amount to as much as several tenths of a volt.

In other words, down at the bottom here we have little cells where a particle of iron carbide and a crystal of iron in close contact have potentials of one to three-tenths of a volt, and those little cells will have much greater voltage than you have impressed on this whole system, and therefore the surface of the iron pipe has a small galvanic cell, and those small galvanic cells,—take your inhibitor, which is plating solution in copper, and plate out the metal without any external action. They will plate out a small amount of lead and copper. That is the way the lead and copper acts as inhibitor. It doesn't need this outside current.

It has several tenths of a volt out in the open. A piece of pipe in the open with hydrochloric acid, or any water solution, on that surface there are differences of potential several tenths of a volt. We have that potential and we put a solution with a little bit of lead and copper in it. The current in that little galvanic cell causes the electrical chemical cell action and plates the lead on one of those electrodes.

Now, if we impress another one hundredths of a volt of copper from some source outside, say three thousand feet away, and with a resistance between it, we are not going to get any greater effect or any protection on this metal in solution, and therefore the metal in solution combined with the differences in potential that exists in the steel itself, the lead plates out to some degree, the copper plates out quite thoroughly, and you get a protective film formed on the

surface of the iron just by immersion of the steel in this lead and copper containing solution.

The Court: Well, lead chloride and copper chloride, do they have the possibilities for the little electric current just the same as the free copper? A. They are somewhat different in that you plate on a perfect film of lead, it doesn't act quite the same way as a sheet of lead. That is 100% lead, and you get a definite voltage or the tendency for that lead to dissolve but if you just partially cover it with a few atoms, you don't get quite as high voltage.

The Court: Is this plate we talk about of lead free lead just like our lead plate is when we start or is that coating like the particles that are floating through the acid and really lead chloride? A. It is metallic lead. It is small particles of metallic lead, and it isn't lead chloride.

The Court: Well, now as it is, on its way across that, of course, has its origin in the lead plate and it winds up as a thin coating some place at a little or great distance. On its way over there is it free lead or lead chloride? A. It is a lead ion with a valance of two and an atom of lead with two electrons removed from it. Completely different.

The Court: It is hooked up— A. With chloride.

The Court: That is on its way over it goes to pieces again? A. It is plated out. If you will let me, I will show you how lead chloride solution and copper chloride solution—

The Court (interposing): I want to see after it leaves as free lead and winds up as free lead, as I understand it, it gets a ride across there with some new neighbors. A. Yes.

The Court: Whether it comes out in a parachute or what, I don't know, but after it takes that trip across it gets out as free lead again. A. Well, now, the first thing I want to explain is what happens when you take a piece of ordinary steel and immerse it into hydrochloric acid which contains lead chloride and some copper chloride. We will assume the lead is the material that is going to do the inhibiting. We have shown in various tests it does a little. I will explain how it does it. There is no free lead in this

system whatsoever—it is just taking a piece of metal, steel, immersing it into a solution of hydrochloric acid that contains the lead chloride in solution. I haven't taken up the lead chloride.

The Court: You have just got lead chloride then? A. We have just lead chloride without any lead sheet at all (indicating). If we consider a piece of steel, in the structure of steel there are crystals of various materials present in the steel that crystallize out, and some of those crystals, the major part of them, are crystallizing pure iron or ferrite (indicating on the board). Now, let us assume that we have some ferrite crystals here, covering most of the surface, but in steel we have other elements than iron; we have carbon; we have sulphur and phosphorus, and those elements combine with iron to form compounds, and those compounds, when the steel solidifies, they crystallize out and form small particles and crystallize around through the surface.

The Court: Some of them are better for some uses, for certain uses, and some worse for certain uses. A. That is correct. So we will consider that these are iron crystals, and let us consider here—I want to draw it large enough so that you can see it—this is a particle of Fe_3C , or cementite, which is the common form in which carbon occurs in steel. So we have here a particle of cementite in the surface of steel.

The Court: I am to think of those as separate molecules? A. They are not separate molecules. They are separate crystals. You can see them under the microscope. They aren't down to the molecules. They are large enough to be seen under the microscope.

The Court: But made up of many molecules? A. Made up of many molecules.

The Court: They are not all alike? A. They are not all alike. In the case of the Fe_3C , there is different, very small crystals of Fe_3C , and the ferrite is considerably larger in size. The ferrite crystals, being in larger amount, why, they crystallize and tend to form larger crystals. The amount of iron carbide is usually less than 1 per cent, and,

Dr. Carl F. Prutton

therefore, there is such a small amount coming out the crystals are usually finer, and this particular arrangement, the iron crystal in electrical contact in the body of the steel with another material, Fe_3C , two different materials in electrical contact, that is, two crystals which are touching each other electrically in the piece of steel—we are looking through a cross-section of the piece of steel—outside here, if we put on the surface some water solution, and let's put hydrochloric acid, in the solution, this is what occurs. First the iron has a definite potential or tendency to go into solution, which we call its solution tension. It has a very strong tendency to go into solution. The iron carbide very little. We usually measure those differences in tendency to dissolve by the voltage, which is the electrical pressure tending to go into solution. This iron has a very great tendency to go into solution. This material has substantially none, practically zero. It is quite inert.

The iron is a material that tends to dissolve. Now, here we have, if we measure the voltage between the iron and iron carbide, we find it is in the order of one to three-tenths of a volt, which is a fair voltage. The difference in potential right in two adjacent crystals here, we have a water solution on top in contact with these two dissimilar particles.

The Court: I thought we had hydrochloric acid. A. That is a water solution, hydrochloric. We have three-tenths of a volt difference. This force is there tending to throw the iron out into solution.

The Court: Yes. A. That is the driving force for this cell. And we have a complete electro-chemical cell, we have a cell with an electrolyte, two different electrodes at different potentials, and we have the external circuit with the solution, the metallic circuit closed, just as though we had this electrode here or here.

The Court: For all we thought of that as a piece of steel, that we put in, you get that going on within the family. A. It is right inside the body of steel. It is just as though we had a piece of iron here in a galvanic cell, like

a dry cell, and a piece of iron carbide here, and we have .3 volts difference between the two, and then we took and put a bar of steel or something across outside here and dip this in hydrochloric acid. It is exactly the same action.

The Court: In other words, it is the same as if there were two different metals. A. Two different electrodes.

The Court: Like what goes on between copper and iron, or zinc and copper, or lead and iron. A. Yes.

The Court: So as between this kind of iron and this kind of iron, you get a— A. (interposing): That is correct. They are the same action entirely.

The Court: I follow you. A. All right. Now, if we can get this picture—

The Court (interposing): How does that compare with between lead and iron? I mean in strength? A. Well, the lead and iron that we got between this tubing and the tank was on the order of one to two hundredths of a volt, and here we have three-tenths right in the metal itself, in point to point contact with the metal. In other words, the point I want to make is to impress one or two hundredths of a volt on a three or four thousand foot pipe line, you can't do it and hope to do much protecting of this end, while in the iron itself there are differences of potential amounting to a tenth of a volt or more. This iron has this force which is tending to throw iron into solution. And when you take an atom of iron and throw it into solution, iron will not dissolve in water solutions, but it will form a ferrous ion, and the ferrous ions will stay in solution if you have got a negative ion associated with it, and when you do that you produce two negative charges or electrons. And so this force throws an iron ion into solution. The cell is going to act now. The action of the cell is throwing an iron ion into solution. The two electrons go through this circuit. The concentration of electrons in this electrode now is high and the electrons flow through the circuit.

The flow of electricity through a metal conductor is a flow of electrons. It is not a flow of actual particles, like iron atoms. That only takes place in water solutions, where

Dr. Carl F. Prutton

they can move. But in an electric, solid electric conductor, why, it is an electron flow.

The Court: One of them joggling the other. A. Yes. And this electron pressure on this side is considerable. It is three-tenths of a volt difference in electron pressure. Those electrons come over and try to charge this electrode up to the same potentials that they have, which is three-tenths of a volt.

Now, in the solution we have hydrogen ions and chlorine ions, and we have a considerable number of them. And in the solution these ions are moving. We have a passage of current through the external circuit and we are going to have a flow of negatively charged ions in this direction and positively charged ions in that direction. The passage of current through an electrolytic conductor causes a motion of positively charged ions in one direction and a negatively charged in the opposite.

These iron ions go into solution. Then two chlorine ions, which are associated with the hydrochloric acid, two of those come over and simply—they don't hook up solidly with them, but they are in a loose sort of kinetic state of equilibrium with the chlorine ions and iron ion. That is ferrous chloride in solution. That is ionized ferrous ions and chlorine ions.

These two hydrogen ions, which are going in the direction of flow of the positive electricity come here and plate out hydrogen on this electrode, and so we have a film of hydrogen produced on this electrode, and the electrode is converted, now, from an iron, iron carbide electrode, you see, these hydrogens come here, deposit, because the electrons, the two electrons we got off the iron atom came over to this here, and the two electrons add onto the two hydrogen ions, and we have hydrogen deposited. Now we have a hydrogen electrode and an iron electrode.

The Court: What are the hydrogens doing on that iron over there? A. The hydrogen changes this from an iron carbide electrode to a hydrogen electrode. It has a different potential now. The iron carbide had practically no potential, but the hydrogen has some potential.

The Court: Is that detrimental. A. That is detrimental only to this degree—

The Court: Does it affect that iron, now? A. It is not detrimental, but whenever this action occurs that I have described of iron going into solution from the metallic state to the ionic state, you have the corrosion, you have converted some of the steel. Just the hydrogen plates out over there.

The Court: Isn't that protection? A. That is a protection, because the voltage of the cell now drops from about three-tenths of a volt to about one-tenth of a volt.

The Court: That is what I was thinking. It would tend to immunize that. A. Polarize it.

The Court: Cure itself of this danger. A. Yes, it does. It does tend to do that. But in this particular solution it is not sufficient, the hydrogen will not build up a sufficient back voltage or tendency to go into solution to repress the flow of current in this cell to stop corrosion. The corrosion will continue. If you put a piece of steel in hydrochloric acid you will get bubbles evolved, and the action continues and it continues in this particular manner.

The Court: I would think it would be in a receding, a decreasing degree? A. No. On this particular surface, the hydrogen plates out, and then when it gets a thick enough film, bubbles form, and the bubbles escape and uncover the surface of the iron carbide again, and so the action continues.

The Court: There isn't anything there for the hydrogen to hook up with at all? A. No, it is simply hydrogen gas. It has been converted from the ionic state in solution over to hydrogen gas, such as they use for filling balloons, and so forth; and that gas forms a thin film on the surface and then bubbles away. But the voltage of the steel is dropped somewhat from three-tenths maybe down to one or two-tenths of a volt, due to this hydrogen. Hydrogen puts resistance in steel, and that resistance tends to reduce the amount of current that is flowing in the circuit. Now, we are going to put some lead chloride in the solution, and

when we do that the concentration of lead chloride is very low, I mean—

The Court: Do they add that pure iron, every particle of it—if you added all that in, the hydrochloric would not act on it? A. That is substantially true. If you could get a piece of pure iron that had every crystal and every particle of it in exactly the same state, so that there would be no difference in potential—but that is a practical impossibility—they have tried to make pure iron, and they find that the difference in the annealing of one part to another creates a difference in potential. In other words, if you have pure iron with no impurities, if you strike a piece of pure iron with a hammer, the voltage or potential of that struck part is greater than the annealed or—greater than the annealed part that has not been struck at all; and, therefore, you create a potential in C. P. iron, and it is impossible to create a formula without some differences in potential, either due to differences in annealing, due to differences in composition, or the working of the metal, and so you get this difference in potential which starts with this galvanic action.

Well, now, if we put into here some lead salt, like lead chloride, the chloride ions that we would have migrate toward the iron, just as the chloride that was associated in the hydrochloric acid. The lead ions would come over in the direction of flow of the positive ions and try to discharge along with this hydrogen.

The lead ion concentration is so small we get a partial coating out of lead on this surface, and so we get there with the hydrogen and we get a few spots of lead plating out, but that lead has a very important effect upon the action of the cell, although it is present in small amounts. That lead holds the hydrogen film on the surface. It holds the film on the surface to a greater degree than if the lead were not present. The copper does the same thing.

The Court: The lead does not then, if I can use my magnifying glass, it doesn't actually hit the iron and coat the iron, but as I understand it, there is a sandwich and

Dr. Carl F. Prutton

hydrogen is next to it? The hydrogen is next to the iron? A. Here is a particle of lead plated out, and here is another one, and so on, maybe a molecule or two, quite an imperfect coating. Then the hydrogen fills in like this, and those little points hold the hydrogen film on to the surface. Your solution is out here.

The Court: I thought the hydrogen was there before the lead got there? A. No, in this case—

The Court: Over here I didn't have any lead? A. You didn't have any lead in the first case.

The Court: But we had a coating of hydrogen? A. Yes. When you have lead present, they both start coming out together and you get an imperfect plating. There are a number of metals that have that particular action.

The Court: As I understand it, the lead chloride is out in solution? A. It is in solution in the acid.

The Court: And these particles of iron start from a point and find their way around and pick the iron up on a little bit of a coastal trip around to the different kind of iron? A. Yes.

The Court: And in that course they pick up the lead chlorine? A. The chlorine from the lead chloride and the chlorine from the hydrochloric acid. You have ions from both. You have both ions.

The Court: I don't understand everything, chloride and chlorine? A. Chlorine is the element, chlorine. That is the greenish gas. Chlorine is the element and it is not chloride. Chloride ion, Cl is an atom of chlorine.

The Court: Chloride is hitched with any other metal. A. A negative electrode, and to get chloride, the chlorine particle, if we take a chlorine atom, it is electrically neutral. A chlorine atom is electrically neutral, and if we hook two of them together we get the chlorine molecule, which is ordinary chlorine gas that is used for treating water and sterilizing and so forth. But if we hook this chlorine up with a metal then we form chloride, and that ion is different than the chlorine here because it is electrically charged, and the chloride can exist in solution in very high concentration.

Dr. Carl F. Prutton

You can't take chlorine gas and put it in water. It won't dissolve. If you electrolyze it it won't migrate because it is not electrically charged, whereas the chloride ion is electrically charged.

Well, now when we put hydrochloric acid on here we have hydrogen coming out in the impurity, iron dissolving here (indicating) the chloride ions hooked up with the hydrogen ions to make hydrochloric acid. That is hooked up into the solution and you produce ferrous chloride. When you produce ferrous chloride in a piece of iron you have corrosion. So we do everything in this cell. We want to inhibit the action of the cell. We do everything to stop that from functioning when we put inhibitors in. The inhibitors reduce the amount of current flowing into this cell, cut it down and therefore the amount of iron corrosion is reduced because the amount of iron corrosion in this cell is a definite quantity of current for a definite amount of iron.

Putting the lead in, just putting in hydrochloric acid within a few hundredths of a per cent of hydrochloric acid on top of a piece of steel, we get the inhibiting effect with the lead along with the hydrogen. That tends to hold the hydrogen here (indicating) and we put into the cell a tenacious film of gas which has a high resistance and therefore a resistance which reduces the action in the cell. You cut down the current and therefore the corrosion of the iron electrode in this case. So the lead acts in that manner. That is the way which lead and copper act as inhibitors. They form a very imperfect film on the surface of the impurities that tend to hold the hydrogen in place, and that is what is sometimes called polarization and there are other terms used for it. There is a term here of over-voltage, which I have not gone into because I think it is too theoretical.

Mr. Owen: This is a sort of a first lesson, Your Honor. I think we will revert to it later and I want to go to another matter now, with your permission. I am reading from one of defendant's advertisements which was published in March, 1937, and entitled "Howco Method of Protecting Tubing and Casing Against Corrosion While Acid-

Dr. Carl F. Prutton

izing a Well." This quotation is rather lengthy but I have to get it to the witness in order to get the explanation.

(Whereupon the document above referred to was marked PX-186 by the reporter.)

Mr. Owen: Beginning on page 2 under this heading again "Howco Method of Protecting Tubing and Casing Against Corrosion While Acidizing a Well."

"This method consists essentially of using the steel of the tank as one plate of a large battery. The hydrochloric acid in the tank is used as the electrolyte, and installing another plate to form the other electrode of the battery.

"The well known principle of electro chemistry is where corrosion takes place an electric current is produced and conversely where no corrosion takes place no current is produced or if there is no current there is no corrosion. This principle is explained to some extent under the heading of "Passivity," paragraph 3, page 2322, Chemical Engineers' Handbook by John H. Perry, Editor-in-Chief.

"To make this principle easily understood we can refer to the ordinary battery, for example, the dry cell. This battery is made up of two electrodes, one of carbon, and one of zinc with an electrolyte to complete the cell. The manufacturers of such a battery have attempted to make it as efficient as possible, that is, to produce as much current as possible without it becoming polarized. To accomplish this a depolarizer is used. The manufacturers have done this in order to get the maximum possible amount of corrosion which means the maximum possible output of electric current since that is the object of this battery cell.

"If this same cell is constructed without a depolarizer and wires of sufficient size to carry the current are connected from one terminal to the other an electric current will flow. This current would continue to flow as long as corrosion takes place, but would stop very quickly if no depolarizer was used, due to the fact that the positive electrode would become coated with hydrogen, this is called polarization. As soon as the cell became polarized the current would stop flowing and no more corrosion would take place. If an in-

efficient battery is made, polarization will take place immediately. This is the object that is accomplished in the acid tanks. It is done by using a lead plate which has a higher voltage in the natural electrical scale than the iron tank itself. This plate is installed in the tank in such a way that even if a small amount of acid is present, the acid is in contact not only with the tank itself, but also with the lead plate. The lead plate at each end is thoroughly bonded to the tank to make the best possible electrical connection or short circuit. The lead plates in the tank contain over 30 sq. ft. of surface on one side, with both sides considered it is double that amount and this makes a huge battery cell out of the tank when acid is put in it to act as an electrolyte.

"If a tank was so made up and acid placed in it corrosion would immediately start and continue until the tank became completely polarized. This would mean some corrosion to the lead plates and also the tank.

"To save this lead electrode a temporary electrode is placed in the tank and current applied in the proper direction the first time the tank is filled with acid. This is done to complete the polarization in the least possible time, therefore preventing any corrosion that might take place before the tank has had time to become polarized. It is found in laboratory experiments that this voltage applied is not critical and even an excess current flowing will cause electrolysis of the lead, thereby plating the walls of the tank with a very thin coat of lead which only aids in the protection of the tank. After the tank has become thoroughly polarized it no longer needs attention to protect it from corrosion, because even if the tank should become depolarized in spots, with the large size plates a large amount of current would be concentrated at that point and cause very rapid polarization. After the tank has been prepolarized it is filled with acid and taken to the well to be acidized. On arrival at the well a heavy electrical conductor or cable which is well connected to the tank itself is then connected to the tubing or casing to be protected. This is only a means of

Dr. Carl F. Prutton

making the tubing and casing a part of the electrical system of the tank and should be used at all times whether the well is connected to the tank by pipe or tubing because sometimes flexible joints in the tubing may not make a good electrical connection.

"The voltage of the battery formed by the tank is thirty-five hundredths of a volt, therefore it should have a good conductor and as little resistance as possible in the short circuit so that this low voltage current can readily flow from one point to the other. After the tank is connected electrically to the well head the well becomes a part of this large battery and since the tank is polarized before arriving at the well no current is flowing in the system. After the tubing or casing is made a part of the system by connecting it to the tank the acid is started into the tubing or casing. The flow of current immediately goes to the part that is unprotected and is concentrated there, immediately polarizing it. After the acid flows down the pipe in the well, concentrated polarization takes place very rapidly at the point where the acid first comes in contact with the pipe and continues to at each new portion as the acid comes in contact with it. If we consider the lower end of the tubing in a well and assume that the acid has not yet arrived at this point, wherever the acid has been in contact with the tubing polarization has taken place and as the acid moves down to the bottom end of the tubing the polarization and flow of electrical current is concentrated at this unprotected point. The reason is that the acid having been in contact with the upper part of the tubing or casing, has already polarized that part of it so that no more current can flow to the polarized part and no corrosion can take place at that point. Therefore, the polarization will take place as the electric current flows to the lower end if the acid moves to that point and comes in contact with the tubing. The hydrogen that forms on the lower end or unprotected part of the tubing does so immediately when the acid comes in contact with the tubing at that point. It is not necessary for this hydrogen to travel from the tank down through

Dr. Carl F. Prutton

the column of acid to the point of contact on the tubing because the hydrochloric acid molecule that is in contact with the iron is immediately broken down by the electric current into hydrogen and chlorine atoms. The hydrochloric acid atoms that are immediately in contact with the iron are broken down into chlorine ions and hydrogen ions, due to the electrical potential imposed on the acid and the hydrogen ions released from the hydrochloric acid molecule cling to the pipe while the chloride ions immediately combine with the adjacent hydrogen ions, setting free other hydrogen ions which in turn combine with the adjacent chlorine, this all taking place immediately as soon as the current starts to flow. Therefore, one hydrogen atom is replaced at the contact point of the tubing and one chlorine atom at the contact point at the lead plate, all at the instant that the current starts to flow, therefore polarization and consequently protection is very rapid and the pipe is protected at all points where it is in contact with the acid. After the acid has passed on into the formation the pipe is still protected, due to its polarization remaining for some little time afterwards. It has been found by laboratory experiments that using a small steel tank, installing lead plates in it and placing hydrochloric acid in it, that the acid could be left for weeks without damaging the tank. That acid taken from this tank was not inhibited because it would immediately start corrosion if iron was placed in it.

"But so long as the lead plates were present and the electrical connection made the battery formed in this manner prevented corrosion from taking place and the acid was not active while these conditions were present."

Mr. Owen, continuing: Doctor, I wish you would state very briefly what you understand this advertisement to mean, and particularly with reference to the statement that the polarization of the truck tank is accomplished from an external source, and that the polarization of the well tubing takes place immediately when the acid comes in contact with it?

Mr. Lyon: If Your Honor please, to avoid any con-

Dr. Carl F. Prutton

fusion in the record, I would like to object to this term "advertisement." I do not know by what authority counsel states that this is an advertisement.

Mr. Owen: When Mr. Clason's deposition was taken, this advertisement was produced by him, and it was identified in connection with his deposition. Mr. Clason is here.

Mr. Lyon: Is it an advertisement?

Mr. Owen: Here is Mr. Clason. Let us ask him.

Mr. Owen: All I want from Mr. Clason is whether this circular or folder was distributed broadly throughout the trade.

Mr. Clason: It was distributed to our men, who I do not doubt gave it to some of our customers.

Mr. Owen: You sent quantities of these pamphlets to each of your stations, did you not?

Mr. Clason: Yes.

Mr. Owen: And they were intended to be handed out to your customers, or prospective customers?

Mr. Clason: Yes.

Mr. Lyon: Who was it written by?

Mr. Owen: I don't think it is of any importance. Well, who did write it?

Mr. Clason: Mr. A. D. Stoddard, vice-president in charge of our shops and plant there.

Mr. Owen: It expresses his views, as you understand them?

Mr. Clason: As an engineer.

The Court: What is that?

Mr. Clason: As an electrical engineer.

The Court: He is an electrical engineer?

Mr. Clason: Yes.

A. (Dr Prutton): The article which you have just read very definitely claims that the purpose of the lead plate in the truck tank is to inhibit the corrosion of the oil well tubing in the well, and claims that that is accomplished. The claim is also made that they polarize the truck tank with an external method other than just the lead sheet alone before placing it in service, and that the tubing is protected also by this electrolytic protection method.

L

Dr. Carl F. Prutton

Mr. Owen: Well, now, what is the fact, as you understand it, regarding the protection which is provided against corrosion in the oil well tubing due to the presence of the lead plates in the truck tanks of the defendant company?

A. As a result of the large scale tests that I have made, which clearly show that the lead plate exerts no electrical protection effect, the reduction in corrosiveness which they apparently obtain in service in the tubing is due to the inhibitors contained in the acid, and not to any electrical effect. That is my conclusion, both from theoretical grounds and from the results of the many tests that we have run.

Q. And what does the presence of the lead plates in the tank have to do with the presence of the inhibitors in the acid which goes down the well tubing? A. The lead plate supplies most of the lead chloride content of the acid just before it goes down the tubing, and it supplies probably a majority of the copper content of the acid, the two, the two metals which are the inhibitors in the acid entering the well.

Q. Now, when copper chloride and lead chloride are in solution in hydrochloric acid, does it make any difference in the inhibiting effect whether they are added to the acid in the form of copper or lead chloride or are produced in the acid due to the presence of lead plates or other materials from which those chlorides may be produced? A. There would be absolutely no difference. The materials would be identically the same. If you take lead chloride and dissolve it in acid you get a solution. If you take a piece of lead and dissolve it in hydrochloric acid you get lead chloride, and if you simply dilute that with more acid you have the same thing which you would get by taking either solid lead chloride and dissolving it in the acid, or first dissolved the lead to make lead chloride and then, putting it in the acid, and the same thing would follow with copper.

The Court: I think I would like to have the doctor point out the particular things in there with which he disagrees, if he disagrees with that article. I think I get it from what he said.

Dr. Carl F. Prutton

Q. Will you do that, Doctor? A. That is rather a long order. The explanation of the electro-chemical changes and how they take place in there are very unorthodox, and are written evidently by a man who is an electrical man, as they state, but not an electro-chemist that really knows what happens in a solution, and it is not hitched together in each little detail. The thing is quite garbled, and the whole story that it tells is completely incorrect, in my opinion.

The Court: I will accept that as the answer to my question without pressing it further. A. His explanation of breaking up of hydrochloric acid is not thorough. And the vague interpretation I would make of it is it is not even correct.

Mr. Owen: Doctor, referring to your large scale tests, in some of which you stated that you added lead chloride, copper chloride and iron chloride to hydrochloric acid in a steel, or in a stoneware crock, and in others of which you placed hydrochloric acid in a steel tank made to simulate that of the defendant company, and in those tests lead chloride and copper chloride and iron chloride were produced, did you find in those tests any different effect in those where you added the chlorides and in those where you produced them through the presence of the lead plate and the contact with the acid and so forth? A. We got substantially the same inhibiting effect whether the metal was placed in the acid dissolving the salts or whether we put the acid into the tank and let it dissolve the lead plate in the tank, producing the salts in the solution.

Q. Well, in this advertising literature which I read, I repeat this statement:

(Reading): "It has been found by laboratory experiments that using a small steel tank, installing lead plates in it and placing hydrochloric acid in it, that the acid could be left for weeks without damaging the tank. That acid taken from this tank was not inhibited because it would immediately start corrosion if iron was placed in it."

How does that statement agree with your experiments?

A. I think that there is a slight element of truth in that

statement. In other words, if you had acid in this steel tank with the lead plate on the bottom, the lead dissolves, the copper dissolves, to make an inhibited solution, and you get some small amount of electrolytic protection on that tank, because the lead is so close to the iron there, just adjacent to it. But if you take some of that acid out and put it on iron, it would act on the iron. Any acid will act on iron, even when it is inhibited, as well as we can inhibit. There is always some action. And, therefore, to say that it would attack iron is perfectly correct, but it would not attack iron anywhere nearly as much as commercial hydrochloric acid would attack it. The acid is definitely inhibited, and that is incorrect in that statement that you read to me. It states that the acid is not inhibited, and I state that it is inhibited.

Q. Have you made any tests to determine the amount of protection against corrosion that results from the mercaptans found in Michigan crude oil? A. We have made some tests to study the effect of Michigan crude oil upon attack of acid upon oil well tubing, and the oil which we used was obtained from the Zahn well, which is one of the wells in suit, I believe, or in question here. I have the results of those tests.

Q. Will you explain those tests and the results? A. There were three different sets of test conditions. These tests were run upon the one-inch lengths of oil well tubing that I described before, that we used in our laboratory scale inhibition tests. We took chemically pure hydrochloric acid, and diluted it to 15 per cent, and measured the rate of attack of that 15 per cent C. P. hydrochloric upon the lengths of oil well tubing. We then took some 15 per cent C. P. hydrochloric acid, and added to it lead chloride alone in the amount of 340 parts per million of lead, and ran the corrosiveness of that acid upon the oil well tubing. We then took C. P. hydrochloric acid 15 per cent, and added to it 340 parts of lead, that is lead chloride, 380 parts per million of iron, in the form of ferrous chloride, and 3.8 parts per million of copper, in the form of cuprous chloride. So

Dr. Carl F. Prutton

we had three different acids that we used, the C. P. diluted, the C. P. diluted plus lead, and the C. P. diluted with iron, lead and copper in it.

Now, the first test was made without any oil being present. They were made without any oil present. And, of course, we took the—we measured the decrease in rate of attack or the percentage of inhibition of the acids, and we took the fifteen per cent C. P. as the reference point. There was a one hundred per cent rate of attack or a zero per cent inhibition. That is the reference point. The addition of 380 parts per million of lead in the form of lead chloride reduced the corrosiveness by 9.3 per cent. When the copper, iron and lead were incorporated in the acid, the reduction in corrosiveness was 62.1 per cent. That is the first series of tests run without oil.

The second series were run with oil in the test. The one inch length of oil well tubing was dipped into the crude oil for several minutes, removed, and allowed to drain for several minutes, and then the oil-coated ring was placed into the test bottle containing the acid. The fifteen per cent C. P. hydrochloric acid, the inhibiting effect of this oil film on that particular sample reduced the corrosiveness by 12.1 per cent. In other words, this oil film on the pipe reduced the rate of corrosion by a little over twelve per cent. The acid that contained the lead chloride, when we placed the oil soaked length of oil well tubing into it, it reduced the corrosiveness by 21.9 per cent.

Q. As compared with what without the oil? A. Without the oil it was 9.3. In other words, there was about twelve per cent effect of the oil added onto the lead. In other words, the oil inhibition is additive to the metal inhibition. The lead chloride conferred inhibition and then the oil conferred additional inhibition on top of that.

The third test or the third acid was the chemically pure acid which contained, as I said, iron, copper and lead chlorides, and the reduction in corrosiveness was 70.5 per cent. The oil contributed to the inhibiting effect of the three metals present by 8.4 per cent. Now, the third set of con-

Dr. Carl F. Prutton

ditions was to take the acid which was to be used in the test and add to it two per cent of its volume of crude oil, shake the oil up with the acid, and then immerse the clean steel specimen into that oil emulsion in the acid. The first test using that method, using C. P. fifteen per cent hydrochloric acid, the reduction in corrosiveness was 20.4 per cent. Applying the oil in that manner reduced the corrosiveness of the acid 20.4 per cent. When the acid containing the lead chloride was used, the reduction in corrosiveness was 28.2 per cent. Now, if you will recall, the lead chloride and the acid without any oil present at all was about 9 per cent reduced. With the oil present, and the lead chloride, it is 28 per cent. The oil alone gave 20 per cent. And, therefore, the two are substantially additive. The inhibiting effect of the oil adds on top of the inhibiting effect of the metal.

In going over to the acid which contained all three metals present, and employing this method of shaking the oil up with the acid before immersing the sample, the reduction in corrosiveness was 75.7 per cent. Again showing that the oil contributes additional inhibiting properties to the inhibiting properties of the metals that are present in the acid.

Q. Were those tests made with agitation? A. These tests were made without agitation. They were made in the standard manner that I described previously under our laboratory test conditions.

Q. Doctor, referring to the defendant's tanks, will you state whether the formation of copper, lead and iron chlorides is a continuing process so long as the hydrochloric acid is contained in the tanks, and even after they have been initially polarized? A. The process continues, as shown by the fact that the acid in the polarized tank that we used in our tests picked up iron, lead and copper, and we have test data that shows the concentrations that were picked up at the end of one hour, and two hours, and there is a regular progression in the amount of metals picked up, and iron is one, lead and copper the others. It is not a regular thing in the sense of a nice, smooth curve, but it is in the sense that

Dr. Carl F. Prutton

you are comparing between different runs, and I am comparing in one run. We dipped out of this tank, at the end of one hour we took out acid, and we had some at the beginning; and at the end of two hours, and there was a constant increase in the copper content and in the lead content and in the iron content over that six hour agitation period.

The Court: There was not any drop at all? A. No, it was just a constant upward curve, showing how the regular solution of metals went into the acid.

Q. If the acid in the defendant's truck tanks did not contain these inhibitors, would anything result from the cable connection between the tank and the well tubing? A. If we had an uninhibited acid, that is, acid which had these metals in it, and ran it into the well tubing, and we had this lead sheet in the tank—would it protect? It is my opinion that it would not protect.

Q. The question was a little more specific than that, and that is, that if the acid in the defendant's truck tanks did not contain these inhibitors, even disregarding the presence of the lead plates for the moment, if the acid did not contain inhibitors when it leaves the tank, would this cable hook-up have any effect one way or the other? A. No, it would not.

Q. And if the acid does contain inhibitors when it leaves the tank, does the cable hook-up have any effect one way or the other? A. In my opinion it has no effect.

The Court: The whole answer to that in your theory is that it has iron enough to work on, without some more so far away. When you get all through with it that is about what it is, isn't it? A. That is correct.

Mr. Owen: And that whatever protection there is in the well tubing is due to the presence of these inhibiting agents in the acid as it passes through the tubing? A. Yes.

The Court: As I understand you, Doctor, that lead does do some good to the tank, or I mean to whatever—I leave out the word "inhibited"—from preventing the acid from eating the iron of the tank? A. I think it does some slight—has some slight benefit there, possibly reducing the rate of attack some twenty per cent.

Dr. Carl F. Prutton

The Court: When it gets over into the tubing it is so far away it doesn't? A. Yes. In the tank acid, as you recall, the acid leaving that tank is, according to our figures, 75 per cent inhibited due to the chemical inhibitors. Well, with 20 per cent electrolytic protection due to the lead plate and 75 per cent due to the metals in solution, the tanks undoubtedly last quite a length of time.

The Court: How much of that 75 per cent inhibition do you attribute, or do you attribute it at all, to the action of the acid on the lead during the time the acid is in the transportation tank? A. It comes from the lead sheet and possibly some small amount of copper might come from this tank.

The Court: You don't give any of it to the—any appreciable amount, what it does to the tank before? A. I think that lead that is on the side of it, and copper that they take and plate from this lead sheet in the bottom in their polarizing operation, and plate it on the side, partially plate up, I think some of that dissolves too.

The Court: How much will that do the year after next? A. I think it would be all gone in a year. I think it would be all gone in six months.

The Court: If they are right in their contention that is only done once during the life of that tank why, then, during most of the tank life you understand it is negligible?

A. Yes, and that the protection, the polarization is not a major factor, and the chemical inhibition of the metals dissolved from the lead plate then is the major factor in protecting it and then some help is obtained by means of the electrolytic protection of the lead sheet, coupled with the iron. I would think they would get 40 per cent inhibition and possibly something like that with their 20 per cent electrolytic, and maybe 70 per cent from the chemical inhibition.

Mr. Owen: And the 70 per cent could be obtained by dropping in the lead chloride and copper chloride and iron chloride in the absence of the lead plate in the tank? A. That is correct. The result would be the same whether you added the lead chloride or let the lead plate dissolve; if you

Dr. Carl F. Prutton

got the same final concentrations you get the same inhibition.

The Court: But that isn't inhibited as much as the copper and the lead. A. That is right.

Mr. Lyon: I would like to understand the witness' testimony on that point. Is he saying that if we just hung the copper, the lead plate in the tank, in the acid, and didn't connect it to the bottom of the steel, or the wall, we would get the same protection for the tank? A. No, I did not say that. I said you would get, by electrically connecting it, you get additive effect. The amount of it I don't know, but I don't believe it is over a half of the effect.

Mr. Lyon: Suppose we just put raw commercial acid in our tanks, draw them out, but had this same lead plate suspended in the middle of the acid, not in contact with the walls of the tank. Would your testimony be that we would get the same protection? A. Well, I don't think in that case you would get the same protection.

The Court: No.

Mr. Lyon: Would you have the same amount of lead dissolve in the acid in the same length of time? A. I have explained you get some electrolytic protection.

Mr. Lyon: I am not asking you that. Would you have the same amount of lead dissolved in the acid in the same length of time? A. If you didn't have it connected?

Mr. Lyon: Yes; if you did not have the lead in contact with the tank itself? A. I think you would get somewhat less lead dissolved.

Mr. Lyon: How much less? A. I don't know. I don't think it would be over one-third less.

The Court: As I understand the theory, your reason for that answer is it would have farther to carry the lead to get to the iron? A. Well, no. The reason that I would give for that, if you just put the lead plate in the acid without making any connections to the wall of the tank, you wouldn't have a complete electrical circuit, and that the lead that would dissolve would have to dissolve by chemical attack on the lead plate.

Dr. Carl F. Prutton

The Court: You would have two connections between the iron and the lead, but either route would have to be through the acid. A. Yes.

The Court: You would have no direct metal to metal contact. A. No.

The Court: But you would have two routes. A. Through acid. And that is not a complete electrolytic cell, and the fact that I have said you get electrolytic protection indicates that there is current flowing through your cell when you have the lead plate in contact with the bottom, and that current flowing does dissolve more lead. So you would get more lead in solution with that cell in contact than you would without it being in contact.

The Court: In other words, you think one copper wire connected from the lead to the steel somewhere would do some good? A. Yes. It would do some good on this 20 or 30 per cent inhibition as I have admitted in my opinion, the electrolytic protection does help out in the steel tank to some degree.

Mr. Owen: Have you made any tests with a view to determining the effect of pressure on the action of the inhibited hydrochloric acid? A. We have made a series of tests on a laboratory scale to determine the effect of pressure upon the inhibition of various materials when added to hydrochloric acid solutions. The tests were run using prepared strips of strap iron that were immersed in a two-inch diameter glass test tube containing the acid, that glass test tube was placed inside of a heavy-walled alloy steel bomb and the pressure of one thousand pounds per square inch of nitrogen gas, which is an inert gas, was applied above the sample. And the loss in weight of the samples was determined under those conditions. We also ran a loss in weight of the strap iron in the acid in the two-inch test tube when exposed to the air, or open to the air, at atmospheric pressure, the same temperature and length of time test.

The general conclusion, and there is no major difference, is that the different types of inhibitors, with them you get the same relative reduction in corrosiveness rate at high

Dr. Carl F. Prutton

pressures as you do at atmospheric pressure. It is the same percentage reduction in corrosiveness. However, the actual corrosiveness of the acids is somewhat reduced.

In other words, same thing, C. P. hydrochloric acid 15 per cent, if that would lose one gram of iron during the test, at atmospheric pressure, under 1000 pounds pressure, why, that C. P. 15 per cent acid would dissolve maybe seven-tenths of a gram. But when you added inhibitor to the 15 per cent hydrochloric acid, you would get a similar reduction in rate of attack with the inhibited acid. So that the percentage reduction is substantially the same. If you want the figures I can give you a table of figures, but, if not, the general conclusion is simply that the rate of attack of the acid is reduced by pressure, whether the acid is inhibited, or not, but the percentage reduction in corrosiveness, the percentage inhibition remains substantially the same.

Q. You testified, Doctor, that 9.3 pounds of iron would be dissolved in one hour of contact between raw 15 per cent hydrochloric acid, in 1000 feet of 2-inch oil well pipe—at least that is as I understood your testimony. A. Yes.

Q. Can you state how much loss in strength to the acid contained in that 1000 feet of pipe would take place in dissolving 9.3 pounds of iron? A. The amount of acid that would be consumed in dissolving 9.3 pounds of iron would be $73/56$ ths of 9.3 or 1.3 times 9.3, which is 12.1 pounds of HCl would be consumed.

Q. How much would that reduce the strength of the hydrochloric acid, assuming that it was 15 per cent when the reaction began? A. Now you are assuming we just fill this tube with the acid and leave it for an hour. I will have to calculate the volume of that 2-inch tube to figure the amount of acid that it would contain.

Q. Well, Doctor, will you compute that and give us the answer? A. You want to know if I filled this 1000-foot length of 2" tubing with 15% acid and let it stand for one hour, what reduction in strength would occur. I will compute it later. I prefer to.

Q. When you are making that computation, I wish you

Dr. Carl F. Prutton

would also apply your same calculations to seven-hour contact between the acid and the well pipe, the tubing being 3000 feet long and 2½" in diameter. A. I have the figures for 7.1 hours' contact, 3300 feet long and 2.66" in diameter. In this 7.1 hours of contact, 3300 feet length of tubing, and the inside diameter of 2.66", 273 pounds of iron would have been dissolved, 355 pounds of HCl consumed, or 265 gallons of 15% HCl would have been destroyed. The 265 gallons of 15% HCl would have been destroyed.

Q. And can you tell how many gallons of HCl would have been contained in that 3000 feet of pipe? A. I don't have that figure but if you ran through 1000 gallons you would get out 735 gallons of effective acid out of the bottom. If you ran through 500, 235 gallons of undestroyed acid out the bottom, substantially.

Q. That is, if it was raw uninhibited acid. A. Yes, attacking at the rate of 9.3 pounds, 2" pipe, 1000 feet long.

Q. And that rate of 9.3 pounds per hour in a thousand feet of 2" pipe is based upon the results of which of your tests? A. Of my blank runs using the diluted commercial acid without inhibitors.

Q. And those are your runs, 1, 1AA, 2A and 2C? A. That is correct.

Q. Tables I, II, III and IV? A. That is correct.

Q. Have you a chart showing the effect on the rate of corrosion of 15% commercial hydrochloric acid, both the raw acid and inhibited acid, based upon your runs? A. I have such chart. (Chart is produced.)

(The chart was offered and admitted as PX-187.)

Q. Will you please explain that chart, doctor? A. In this chart the upper line going across the chart indicates the corrosiveness of the 15% commercial hydrochloric acid without inhibitors, as measured in our large scale tests. The length of that line (indicating) indicates 100% corrosiveness, and referring to that acid as being 100% corrosive.

The amount of corrosion has been calculated for this

Dr. Carl F. Prutton

chart to be in these blank runs, or the runs made with the commercial hydrochloric acid, 485 grams of iron; that was the average that was dissolved from the oil well tubing by 100 gallons of the 15 per cent acid that was run through the tubing. That is taken as the standard of corrosiveness.

Now, when we run—when we add to the acid various amounts of copper, lead and iron, in the form of chlorides, we get a reduction in corrosiveness, and the amount of reduction in corrosiveness, the percentage reduction in corrosiveness in run 1-B, which we ran, where we took the 15 per cent commercial acid in the stoneware crock, and added the metallic chlorides to it, agitated them, and then ran directly from that stoneware crock to the piping system, there was 75.6 per cent reduction in corrosiveness, as compared with the commercial acid, or 75.6 per cent inhibition compared to commercial acid.

In run 2-B, which is shown in this third line, in which the copper content was 3.07 parts per million; lead, 316 parts per million, and iron 2315 parts per million, the reduction of corrosiveness was 66½ per cent.

In run 2-D, with 3.71 parts per million of copper, 455 parts per million of lead, and 418 parts per million of iron, the reduction in corrosiveness was 77.6 per cent.

In run 2-E, shown in the last column, with 3.8 parts per million of copper, 340 parts per million of lead, and 382 parts per million of iron, there was 89.1 per cent reduction in corrosiveness, as compared with the commercial acid used.

Q. Have you also a chart showing similar information in connection with your runs using the simulated Menaul tank or Halliburton tank? A. I have such a chart. This chart shows the reduction in corrosiveness that was obtained in these tanks employing the simulated Menaul type tank, and the first line of the chart, the first heavy black line indicates the corrosiveness of 15 per cent commercial hydrochloric acid when run through the piping system directly from the stoneware crock without the Menaul tank.

That is our reference point in our comparison of cor-

Dr. Carl F. Prutton

rosiveness. In this the corrosive effect of the commercial acid without any lead plates or anything in it is shown, and that is the rate of attack and it is 485 grams per 100 gallons of acid passed through the system, which is identical with the reference figures in the first chart.

(The chart was offered and admitted as PX-188.)

Q. That was the same basis as in PX-187, the previous chart? A. That is correct. Now, in the second line the figures for run 1-N are given.

Q. Now explain again what that run 1-N was? A. Run 1-N was a run made with the Menaul type tank in which the acid was 15 per cent commercial hydrochloric, which was run from the stoneware crock into the Menaul tank, agitated for about six hours and then run from that tank through the tubing system and the tank and the tubing system were connected together with a copper wire in order to practice the Menaul process of inhibiting the corrosion of oil well tubing. The conscript "M" in these runs indicates the ones that practice the Menaul process, and the number 1 indicates simply that we used the No. 1 series of tubing. And in this result we got 66.6 per cent reduction in corrosiveness, this particular test, with the cable connecting the tank and the tube. In the third line run 1-M is given, and in that the wire was disconnected, but the Menaul tank was used, same condition, other than disconnecting our wire. 68.8 per cent reduction in corrosiveness was obtained.

In run 2-M, that is, the fourth line, heavy black line, horizontal black line, run 2-M is given, the figures for it. That was the Menaul tank using the steel tank, the lead sheet in it, the tubing system, the electric cable between the tube connecting them together, as described in the Menaul patent, and in that test the reduction in corrosiveness was 70.8 per cent.

In the last horizontal line, run 2-N is given. 2-N is a run in which the cable was disconnected, the Menaul tank was used, and the number 2 signifies that Series 2 tubing was used, an entirely different set of tubing, and the reduction in corrosiveness in that test was 78.5 per cent.

Dr. Carl F. Prutton

So you can compare 1-M and 1-N, with the wire connected, 66.6, and with the wire disconnected 63.8. They are about the same. 2-M and 2-N can be compared, 70.8 with the wire connected and 78.5 with it disconnected. And if you average them up, why it shows that the wire does a little good and the other shows it does a little harm, but substantially the figures are within the accuracy claimed for these tests, and there is no appreciable effect of that copper wire, which is essential in practicing the Menaul process.

The Court: Have you ever run more than those two tests? I am wondering whether there was just the one. A. Of course, there are four tests there.

The Court: About half the time more and half the time less. In other words, it indicates it makes no difference. A. These were the only tests that we have run on the Menaul process. We have some other tests that were run but were not reported, and I think we are going to report those later on. That for some reason or other there was a deviation, for example, we ran one test in which we tried to run the acid through the Menaul tank so fast it could not be inhibited, and run it in and immediately run it out, but we found even in that case we got 50 per cent inhibition. In other words, we wanted to test its electrical effect with the whole set up connected, and we could not run it through fast enough to avoid contamination of the acid. And these are the tests that we have run.

Q. Now, Doctor, have you also a chart which shows the results of your tests, your laboratory tests, using C. P. hydrochloric acid? A. We have such a chart.

(The chart was offered and admitted as PX-189.)

A. In this chart, the reduction in corrosiveness was obtained by the addition of small amounts of copper, lead and iron to chemically pure hydrochloric acid, and the results are shown. In the first line, horizontal line, is shown the corrosiveness of hydrochloric acid, which is taken as one hundred per cent. Fifteen per cent hydrochloric acid is taken as one hundred per cent. Then, in the second line,

Dr. Carl F. Prutton

the results obtained with this fifteen per cent C. P. hydrochloric was taken, and 2.14 parts per million of copper were added, 242 parts per million of lead and 473 parts per million of iron were added in the form of chlorides. And when that solution was run in the laboratory tests the reduction in corrosiveness was 59.7 per cent.

In the third test, the third horizontal line, to the fifteen per cent hydrochloric, C. P. hydrochloric, was added the same amounts of lead and iron as we had in Test 2, but the copper was stepped up from 2.14 parts per million to 3.72 parts per million, and the reduction in corrosiveness, by increasing the copper from 2.14 to 3.72 parts per million, the reduction in corrosiveness which we obtained was 70 per cent on that sample. In other words, about 10.3 additional inhibition by the doubling of the copper content, or almost doubling.

Test 4 is shown in the fourth horizontal line. To the fifteen per cent C. P. hydrochloric acid was added 1.86 parts per million of copper, 510 parts per million of lead, and 473 parts per million of iron. The 1.86 is supposed to duplicate the copper content of Test 2. In other words, it is substantially two parts per million. The iron remains the same as it was in the first two tests, but the lead is increased to about double the content it had before. And the corrosiveness of that sample showed the acid was reduced 62.7 per cent. The inhibition was 62.7 per cent.

In other words, three per cent increase over that of the mixture in Test 2. Test 2 had two parts of copper and 240 of lead and 473 of iron. Keeping the copper and also the iron—keeping the copper at 2 and the iron at 473, and jumping the lead up to about 500, gave three per cent additional inhibition in this mixture.

In Test 5, as reported in the fifth column, or, in the fifth horizontal space, or line, 15 per cent C. P. hydrochloric acid, 4.18 parts per million of copper were added; 510 parts per million of lead; and 473 parts per million of iron.

The lead and the iron contents are identical with those reported in the acid used in Test 4. The copper, however, is about doubled.

Dr. Carl F. Prutton

The reduction in corrosiveness obtained with that acid is 71.4 per cent. The doubling of the copper content again reduces the corrosiveness about 8 or 9 per cent.

In Test No. 6, which is shown in the sixth horizontal line, running about two parts per million of copper, 1.86 to be exact; 204 parts per million of lead; and increasing the iron content to 1430 parts per million. That particular solution is supposed to be compared with Test 2.

Now, you see in Test 2, we have about 2 parts per million of copper, 242 parts per million of lead; and here we have 204 only of lead, but we have shown that the changing of lead does not greatly affect the inhibition; and this is about in the same order of magnitude. Now, we are increasing the iron, about tripling the iron concentration, and we get 61 per cent reduction in corrosiveness. If you will compare that with Test No. 2, you will see that they are about the same; 1.3 per cent is actually shown, but I think the method is—I think 1 per cent would be a permissible variation in tests.

Now, going to the last horizontal line, which is No. 7, we used 3.44 parts per million of copper; 530 parts per million of lead; and 1440 parts per million of iron. That should be compared with Test No. 3, although the copper is a trifle lower, but the lead is about the same—the copper is substantially the same, and the iron is about three times as great.

Q. The lead is considerably more, isn't it, Doctor, in Test No. 7 than Test No. 3? A. Now, wait a minute. Wait until I get this straight now (indicating). 7 and 5 are the tests that should be compared. In Test No. 5 there was 4.18 parts per million of copper; 510 parts per million of lead; 473 parts per million of iron. In Test No. 7 there are 3.44 parts per million of copper; 530 of lead. Copper is a little lower, but the lead is substantially identical with Test No. 5. The iron is more than tripled, just about tripled. So the net change is largely on the iron, tripling the iron. A reduction in corrosiveness is reached of 70.5 in this case, whereas up above there it is 71.4. There is a little more

Dr. Carl F. Prutton

copper in Test 5, and that would probably account for the difference. But the effect of the iron is shown to be negligible in these tests, there is substantially no effect by adding iron. Lead has some definite effect, and the copper has a very appreciable effect upon the inhibition:

These tests, the laboratory tests, if you compare those with the actual flow tests, they are very comparative; these figures all are of the same order of magnitude. In the laboratory tests we obtained about one-third to one-quarter as much corrosion with the inhibited samples, as we did with the uninhibited acid, and that same thing is true in the tube tests that we made. It is expected in the laboratory tests that we would get slightly lower inhibition because of the fact that there is no agitation in the laboratory tests.

The Court: Let me see if I understand you. In 4 why do you get more than you do in 2, and you have less copper? A. Why in Test 4 do I get more inhibition than I do in 2, when I have more copper? The copper was supposed to be made up to 2 parts per million in the samples. Our analyses shows, as given on the chart, the determination of copper is no more accurate than about .2 parts per million. Therefore, to all intents and purposes, these two samples have the same copper content. The amount of copper added was identical.

Mr. Owen: In Test No. 4 you had more than twice as much lead as you did in No. 2. A. I was coming to that. The copper was within the error of the method of analysis of about .2 parts per million. The lead about 3%. The increase in lead gave about 3% reduction in corrosiveness. Doubling the lead content gave about 3% increase in inhibition.

The Court: Have you got this close enough so that you, with your figures showing the combination, do you think you could work out figures as to how much corrosiveness you would have or how much inhibition, which is the same thing, without analyzing it? A. I think I could tell you pretty close if you wanted to know how many parts per million, if you said what inhibition would you get with 3

Dr. Carl F. Prutton

parts per million of copper, 400 of iron and 500 of lead. I could tell you that very quickly. The whole thing this shows in a general way is you get between 60 and 70% inhibition with acids that contain iron, lead and copper in such amounts as we got into our Menaul tank acid or in amounts reported in defendant's acid as taken directly from their truck tanks. These compositions cover the range of all those acids and the 10% would cover the whole group. In other words, once you get up to 2 parts per million of copper, a couple hundred parts per million of lead, you get to 60-70% inhibition. You may get another 10% if you double the copper, a little more by doubling the lead, but you are up near the optimum condition of inhibition with that condition of copper, lead and iron. These cover the composition of field samples of Dr. Bartell and cover the combinations of acids we got when we put it in the Menaul tank and shook it up for six hours.

The Court: I am looking at No. 6 and No. 4, and I am wondering why the more than doubling the amount of lead practically made no difference. What was your explanation about that? A. Test 4, the inhibition is 62.7 and in Test 6 the inhibition is 61. That is 1.7 per cent due to doubling the lead. There is not a great deal of change.

The Court: You are more than doubling your lead. A. More than double, yes. It is around two per cent change, and the other figure was three. But in all the tests we have run increasing lead up to about 200 parts per million you get about eight to ten per cent inhibition, and if you go above 200, going to 500, you get another one or two or three per cent, so it goes up to a little over ten as a rule.

The Court: What is your final conclusion about iron? A. That it has practically no effect whatsoever. You don't want to take these figures—I regret they reported these percentages in fractional percentages. The best thing is to take them as whole numbers, and the accuracy of an inhibition test isn't sufficient to warrant these percentages, and therefore I would rather stand on whole number differences.

The Court: I was treating 62 in 7 and 61 in 6 as being

Dr. Carl F. Prutton

practically the same. A. Yes. You see, Test 2 and Test 6 have about the same copper and same lead, and the iron is tripled, and it is 1.3 per cent difference between the two. And that is coming very close to the sensitivity of the method.

The Court: All right.

Mr. Owen: Doctor Prutton, did you run any other tests than those covered by your tables which have been offered as PX-187, 188 and 189? A. We ran several other tests which are not reported in the report involving running uninhibited fifteen per cent acid through a tubing system. Another test running it through the Menaul tank and then through the system, and one test in which, to the commercial acid, chemicals were added and then it was run through the tubing system direct, and those figures were not reported.

The general results of the tests, the first test run with commercial acid was run as a sort of a measure of how we could rely upon the—how constant would be the rate of corrosion of different lengths of oil well tubing, and we used a set of tubing which was not used in subsequent runs, and we found that the variation in corrosion of different lengths of tubing in that system varied by as much as twenty-five per cent. So we decided in subsequent runs to fix on two completely separate identical sets of tubing that we would follow through in the tests.

The result of the first test agrees in general with the blanks we ran on other samples, or on other tests. But since we did not follow through and run that same tubing throughout all the Menaul and other type tests, we did not include it. The rate of attack of the tubing in that first run was substantially the same order of magnitude as in the other blank runs. It wouldn't change the picture to any degree at all if it were included.

The second run that was discarded was a run that I mentioned this morning in which we ran fifteen per cent commercial hydrochloric acid through the Menaul tank and we tried to do it so fast that it would not have time to pick

Dr. Carl F. Prutton

up lead and copper. And when we finished up we found that about fifty per cent inhibition had been obtained by the exit acid. The acid from the Menaul tank showed 1.3 parts per million of copper which would account for about that fifty per cent inhibition. And since the result was not clear cut, that was not included.

Then a third test was not included in which we made up a synthetic mixture of these chemicals added to the acid, running directly from the crock through the oil well tubing, and when we got through with that run and analyzed the solution we found that some error had been made in the copper addition, and that the analysis showed about 1.4 parts per million of copper, and that particular acid also gave about fifty per cent inhibition, which is about what we would have expected.

Q. Did you run any tests with oil through the horizontal pipes? Your pipe system? A. We ran tests which were not completed. We put some of this oil from the Zahn well in the tubing, and then ran the acid through the system. The flow conditions that we got in which alternate solutions of the oil came out of the tubing with the acid, and the fact that our tubing system was almost horizontal, which would permit the oil to rise to the top of the acid, and the acid flow underneath the oil, and have a very thick column of oil up on the top of the acid layer, we came to a definite conclusion that those tests were not valid, they did not agree in any way with these laboratory tests of the inhibitions in the presence of oil as reported this morning. The inhibition was around 50 to 60% when measured, which we felt was due to the fact a heavy layer of oil floated on top of the acid, the acid had gone beneath it and we really only had half of the metal exposed. In our tests the velocity we ran acid through our system was a very low velocity—less than a half foot per second; when we pump acid down into an oil well in a treatment, the velocity you usually use is around 5 to 8 feet per second. At that velocity you get a tremendous amount of turbulence which scours oil off the tube; you have no turbulence at one-half foot per second—

Dr. Carl F. Prutton

it simply flows in a straight line. Therefore, we felt to make any valid tests to determine the effect of oil that might have been in the tubing we would have to go to a vertical system, to have a pump in the system that would give us the velocity, and we did not complete all the data on those tests because they were all experimental, to get any figures that were representative.

The Court: Is your rapid movement comparable to agitation? A. Very much so, yes. If you increase the velocity of a stream of liquid going through, you get a scouring action. The turbulent currents tend to scour off the oil. The more rapid movement, Dr. Bartell's tests have indicated that you get more rate of solution but you get a greater percentage of inhibition.

The Court: All right. That is attendant, on the one hand, with that agitation you get in your flowing down the well. You have your oil and your acid mixed, or not? A. In the horizontal pipe—the oil was at the top and the acid flowed under the oil.

The Court: Now, where would the oil be going down the well? A. If it went down vertically the slug of acid coming into a column of oil would hit a velocity of 5 feet per second and it would be scouring off. You have a slug in there in which the acid and oil mixed somewhat but the acid forces the oil into the tubing.

The Court: In each of those did you think you got a greater oil inhibition, in this agitated one, which would be like the well, or in the oil segregated at the top, and the acid flowing under it. Which do you think you would get the greater oil inhibition on? A. If the acid flowed down the vertical oil well tube at high velocity, and forcing the oil ahead of it, you would get a lowered effect of the inhibitory properties of the oil, a lower inhibition due to the oil than you would in my test where it was simply being run underneath a thick layer of oil that was covering over half of the pipes.

The Court: What percentage do you think the oil was to the balance of it? A. I really don't know what there was in this pipe.

Dr. Carl F. Prutton

The Court: I was thinking of a very small percentage, like the cream on a milk can, a little skim over the top, of the oil, to a substantial quantity of the acid, compared— A. (interrupting): In this test that we ran, or these preliminary studies to see just what happened when we flowed the stuff through the oil well tubing, the total volume was about six or eight gallons, and there were about two or three gallons of oil there, and it came out in slugs, there was a slug of oil came out every once in a while.

The Court: That would not compare to the total formation. As I understood you, and as I understand it, the oil would be comparatively still, and the other would be flowing under, and, therefore, if you stopped at any one time and compared the amount of oil to the amount of acid, you would not have any fair comparison as to the total percentage of the total amount that passed through the oil? A. I did not feel it was a fair comparison in the test that we could get.

The Court: I was wondering which way the oil worked, though. If it was agitated, you would get a comparatively small amount of oil over the whole surface, wouldn't you? That is, one part of your tube would have as much oil on it as the other? A. Yes.

The Court: On your agitated one? A. Yes.

The Court: Now, in the other, if you are right about the oil being comparatively still to the acid, and flowing under it, I should think you would get almost a complete inhibition right at the point where the oil contacted the tube, and I would think you would get practically no inhibition at the point where the acid contacted. A. That is exactly the reason.

The Court: Therefore I would want to know how much oil you had, how thick the layer of oil was? A. We had no means of measuring that exactly.

Mr. Owen: I understand in this test the doctor first filled the pipe with oil so that the oil was in contact with the entire surface.

The Court: I was in complete accord with him that it

Dr. Carl F. Prutton

was not comparable at all. I didn't know how you could get anything out of an experiment if you didn't have anything to compare it with. A. Can I answer that further? We had thought of setting up a vertical system. When we started to consider, well, if we want to do a thorough job we will have to repeat all the tests, taking in all of the different tests, it became such a complicated thing it would take years to do, and we feel that the laboratory tests are in general indicative of what would happen.

CROSS EXAMINATION

By Mr. Lyon: As I understand your testimony, the agent that constitutes the guilty inhibitor which you accuse in this case is actually the copper. Is that correct? A. The copper apparently contributes the major part of the inhibition.

Q. Well, I would like you to make that just as definite as you can. Is it necessary that there be any lead or iron dissolved in the acid in order for the copper to produce the effect that you have referred to in your testimony here? A. Copper produces alone the major part of the total inhibiting effect of the final acid contribution.

Q. Without the copper, according to your tests, what is the maximum percentage of corrosion, of reduction of corrosion that you could accomplish by dissolving lead or iron in the acid? A. I thought it would be 10 or 15 per cent. Variable figures were obtained, but 10 or 15 per cent is probably—I am not certain that when you take copper and add it to get an inhibiting power of 60 per cent, and then you add lead in a form so that the total mixture is up to 65, we will say, that the lead only does the 5 per cent job. I have no way of telling. There is no more reason for saying that the lead does just that additional 5 per cent than there is in—there is no reason for holding the copper constant and letting the lead take the burden of the decrease.

Q. If I understand you, it does not make much difference after you get up to 5 parts of copper per million

Dr. Carl F. Prutton

in the acid whether there is any more dissolved in the acid, or not, is that correct? A. I really cannot answer that question, simply because I think the highest concentration of copper that we have worked on has been a little over 4 parts per million; and apparently in adding copper to the acid, you get your major effect in the first two parts per million, and that the curve comes up rapidly in the first two, and then it tends to flatten off somewhat. In other words, we got about 60 per cent inhibition, as I recall here, with 2 parts of copper per million, and then if you jumped it up to 4, you got only about 10 more per cent.

Q. All right. Now, what can you tell us about less than two parts per million of copper? A. I can only tell you the indication I gave you on a large scale test in which we got 1.4 parts per million through and got about 50 per cent inhibition. In other words, going from 4 down to 2 dropped another 10 off.

Q. Have you any experience with 1 per cent? A. I don't recall we have any figures.

Q. So far as you know it is more or less a straight line relationship below 2 parts per million? A. No, I think that it drops off rather sharply in there.

Q. You don't remember the drops? You don't know where it drops? A. No. I would suspect around 1, but I don't know. In other words, we have gone as low as 1.4 and the drop-off is rather rapid. It dropped off about 10 per cent in going from 4 to 2, and from 2 to 1.4 it went down another 10.

Q. How long does it take this copper to dissolve in 15 per cent hydrochloric acid in the absence of any lead plate bonded to the steel? A. I don't have any idea. We made no tests on that.

Q. One part in a million of copper, or two parts per million of copper is not very much. Do you think you know whether or not you could operate in an oil well with hydrochloric acid in a practical way without picking up one or two parts per million of copper? A. Well, we obtained about six or eight shipments of hydrochloric acid from the

Dr. Carl F. Prutton

Graselli Chemical Company, which takes a bunch of commercial materials and runs it through a process, handles it several times and ships it out to us and the analyses we got averaged two-tenths of a part per million. I believe that same degree of handling should be carried out without much trouble if conventional methods were employed.

Q. Well now, how did this copper get in this acid in the tests you made in your laboratory? A. It gets in in two ways. Some comes in with the original acid. I don't know how that got in. Some of it comes in—considerable part, by the lead sheet dissolving, the copper associated with the lead dissolves. The rest of it comes in, I believe, from a steel tank which also contains some copper. All steels contain some copper. In the tests we ran the lead sheet in the bottom of the tank became coated with white coating, a lead chloride, that wasn't dissolved in the acid, would not show up in our analyses, and the copper that was associated with that lead reacted and then the lead chloride not dissolved, it is my opinion, went into the acid. In other words, a considerable amount of the lead sheet reacted, then went into the solution. Therefore, the copper going into the acid from the lead was an appreciable amount.

Q. Well, now, did you purposely buy lead plate for your test that contained copper? A. Yes, we did.

Q. Pick one out that had copper in it? A. We did.

Q. Why did you do that? A. Because we had definite instructions the Halliburton Company was using chemical grade sheet lead, which contains copper.

Q. What is a chemical grade of lead? A. I don't know. That is a term.

Q. Could you buy commercial lead plates without copper? A. I recall looking into the A.S.T.M. Handbook, recalling four different grades of commercial lead.

Q. Did any of them have any less content? A. As I recall very definitely there is one—at least one, grade that had practically no copper.

Q. And what was the price? A. I don't know. I was looking at the table of the American Society for Testing Materials.

Dr. Carl F. Prutton

Q. Are you satisfied if the Halliburton Company employed that type of lead plates in its tanks that it wouldn't obtain the effects which are complained of in this case? A. No. I think that the lead and small amount of copper there actually in conjunction with the oil contact you have in the tube all added to the effect, you still had inhibited acid.

Q. Your testimony then is the Halliburton Company couldn't operate its lead plate system for protecting its tanks without their necessarily somewhere in the system picking up enough copper so as to produce the effects complained of in this case? A. If you used commercial hydrochloric acid, such as normally contains a very minute amount of copper and lead, and if you had a steel tank that was relatively free of copper, if you used pure sheet lead, absolutely pure, I believe you still would be putting inhibited acid into the well when you got through with that; because we have shown definitely that with lead alone, you get a 10 or 15 per cent inhibition that is added to whatever your commercial stuff is, you add that 10 or 15 per cent inhibition, and then you are putting it down the well, and that lead has the property of cooperating with the materials in the well, to give you added inhibition, whereas a number of other inhibitors do not have that cooperative property.

Q. Now, was this property of copper, acting in the manner that you have pointed out here, as an inhibitor, known anywhere prior to its use by the Halliburton Company, do you know? A. I think copper is fairly well known as an inhibitor, copper compounds of various types. I do not recall, I cannot give you a reference, but I am quite sure that some inhibitors have used copper.

Q. Did you know that copper was an inhibitor before you studied this Halliburton system? A. Well, I have a vague idea that I did. I cannot recall that.

Q. As a matter of fact, it depends, does it not, on the relation in the electromotive series of copper to iron? A. I do not think that you can make any blanket statement on the electromotive series.

Q. You used to be able to before the announcement of Menaul's discovery, in the Menaul patent? A. The Menaul

Dr. Carl F. Prutton

patent follows exactly the teachings of electro-chemistry, at least in principle, as far as the protection of the tank is concerned; but it does not follow it any farther than that, due to distance and various conditions.

Q. You have read the Menaul patent? A. Yes, but I can't remember every word in it. I don't recall that it is.

Q. Didn't Menaul announce a discovery that in hydrochloric acid lead bore the opposite relationship in the electromotive series to iron from anything published before?

A. It would be a discovery for any one unskilled in electro-chemistry, yes.

Q. Can you point to any literature showing that discovery before the Menaul patent? A. I can point to the fact that the electromotive force series is a series where each element is given a potential, with a sign to show its tendency to dissolve, but that number that is listed there is the potential of that element against a solution, a water solution that contains one ionic weight of that kind of metal, ions per liter, a definite concentration.

Now, we have equations that show how any voltage changes with the change in the ionic concentration of the solution, and it is entirely logical that although lead is shown in the electromotive force series slightly below iron, when you put it in hydrochloric acid where lead chloride is insoluble, and you get low lead ion concentration, it is possible to figure out what would be obtained.

Q. Didn't anybody ever announce the fact that it was so shifted in hydrochloric acid before Menaul, to your knowledge? A. I don't recall that they ever announced it, because it is one of those things that anybody skilled in the calculation could have calculated quite closely, and the facts that you get a very minute potential tending to give electrolytic protection through the lead and hydrochloric acid solution.

Q. Are you familiar with the fact in acting upon Menaul's patent application the examiner referred to Menaul's statement on that point as inoperative and contrary to scientific fact? A. I read the entire file wrapper,

Dr. Carl F. Prutton

and the examiner was not highly skilled in electro-chemistry.

Q. Well, then, an ordinary skilled man didn't know before Menaul's announcements of this shift in the electromotive force of the relationship of lead to iron in hydrochloric acid, at least you can't point to anywhere in the prior art? A. I believe that any college graduate that has taken a course in electro-chemistry would know that such a shift would occur.

Q. Now, what about copper? Do you think—where is it according to the text books made prior to Menaul's invention, in the electromotive force, relative to iron? A. It is down below iron.

Q. Always? A. It is usually below iron.

Q. Well, does it shift to above iron, now, in this system of the defendant's? A. Well, when we talk about these potentials we are talking about a solid piece of metal. When we are talking about the protection we get with copper that plates out slightly on the surface of iron, we are talking about not a solid mass of metal but just a few molecules stuck here or there. It isn't the same thing at all. We have no means of calculating, in an imperfectly covered surface of iron covered with a few molecules of copper, we cannot calculate the potential of the copper or of the iron. Therefore, we are talking about something that is indefinite and the question cannot be answered exactly.

Q. Well, according to what was published in the literature prior to Menaul's patent announcement, copper was below iron in the electromotive series, and if added to hydrochloric acid in the presence of iron should have increased the corrosion? A. That is right; that is correct.

Q. Now, can you show me any announcement to the contrary to tell you, until your own work or Dow's work, in examining the Halliburton system for this case? A. I believe that I could get you instances of where copper had been used as an inhibitor.

Q. Where? A. Well, I can't tell you offhand.

Q. Have you got it? A. No.

Dr. Carl F. Prutton

Q. As a matter of fact, neither you nor the Dow Company or the Halliburton Company knew of this effect of copper which you are relying on in this case until you did this work, or the Dow Company or Dr. Bartell did this work for the purpose of establishing the evidence in this case; isn't that correct? A. I don't believe that is. It is my opinion that the copper effect was known for years before. At the time of the taking out of the Grebe-Sanford patent, I believe.

Q. Will you point to some publication or published statement of that fact? A. I can't do it offhand.

Q. Well, how long will it take you to find? A. I think probably over night.

Q. All right. We will leave that and ask you to be prepared on that in the morning. Well, did you know it before you did this work? A. I believe I did.

Q. Before you started work on this experimental data, did the Dow Company inform you that that was the basis of their position in this case? A. I don't remember.

Q. You didn't discover this stuff about copper in this solution business independently, did you? A. No. I knew of Dr. Bartell's findings as to copper in the samples, and, as I recall, I knew that copper was an inhibitor in the right concentrations when used, and the thing seemed entirely reasonable to me, that it would inhibit. Otherwise, I would have questioned, possibly, the conclusion that had been made by Dr. Bartell.

Q. Why? A. If I believed copper was going to accelerate the corrosion, I would not have swallowed wholeheartedly his statement that copper was the cause of it. Therefore, I was quite sure at that time that I knew that copper was an inhibitor, if used correctly.

Q. Well, you can't find that in any literature, can you? A. Well, I hope to. That is what I said I hope that I can bring in tomorrow morning for you.

Q. Now, how does the copper work? Do you know what its system is or mechanism by which it accomplishes this inhibiting action? A. I believe that both copper and

Dr. Carl F. Prutton

lead work somewhat similar, and that is that in the dissolving of the iron that hydrogen is plated out on the anodic portion—or, I mean, the cathodic portion of the metal, and that an imperfect film of copper and lead are deposited on those areas that hold on to the hydrogen, and build up a hydrogen over-voltage or polarization that stops or reduces the corrosive cell.

Mr. Owen: May I make a statement here, right in connection with this discussion of the inhibiting value of copper, Your Honor, plaintiff will show that the Dow Company used a copper chloride as an inhibitor for hydrochloric acid in acidizing oil wells for two or three years prior to the date of the Menaul invention. A. That is undoubtedly where I learned of it, and possibly from the literature too.

Q. Is it your testimony then that just putting copper chloride in the solution, without any lead plate, without any galvanic cell action, would accomplish this same inhibition, of the same order of magnitude? A. It would accomplish some inhibition.

Q. How much would you have to put in? A. Well, I think we have shown here how much you have to put in. You have got to put in a couple of parts per million.

Q. Of copper chloride? A. In the form of copper chloride.

Q. Is that all that you have to do? A. Just a few parts per million, and you have got about 50 per cent inhibition, approximately.

Q. Well, now, you were discussing the action of the copper in this plating mechanism, and you mentioned the plating of a film of lead or copper. Is it actually necessary that there be any such film at all to accomplish the reduction in corrosion, or may that be accomplished without the plating action of the metal, simply by the polarization? A. Unless you change the surface of the metal, you cannot get any difference in polarization; and, therefore, that is the basis upon which I am stating that some of that metal must be deposited to change the nature of the surface, so that

Dr. Carl F. Prutton

it can hold on to that hydrogen better. If there is no change whatsoever in the surface, you would not get any change in polarization.

Q. Wouldn't you get a hydrogen film? A. You would, but it would not take the high back EMF that stops corrosion, or the high polarization. You would get a slight film that would escape in the form of bubbles, and not be held on there tight.

Q. Now, you criticized the statement of the defendant's chief engineer this morning as read to you. I am going to read to you the paragraph commencing at line 38 on page 3 in the Menaul patent covering the defendant's system, No. 2149617. I think Your Honor has a copy of this patent. First I call your attention to the paragraph commencing at line 55 on page 3, reading "The method of this invention may also be applied to the treatment of tanks or other containers in which acid is stored or shipped, a suitable plate of metal having a more negative external potential than iron in the acid solution, for example lead, is suspended in the acid, then connected with the wire of the steel tank either with or without the medium of a battery or other source of low voltage current. As shown in Fig. 5, for example, the iron tank 12 may have a lead plate 13 in electrical contact with the bottom of the container. Such contact may be obtained either by riveting or burning the lead into place. It is to be remembered that the lead plate or lining should not cover the entire interior surface of the tank but only a part thereof so that the acid contained therein may contact with both the lead and the sheet iron. Desired polarization of the interior of the tank is thus attained." Now, do you disagree with that statement? A. No, I think that is true to a degree.

Q. Well, now, I will next ask you to turn to the paragraph in the next column, commencing at line 37, reading:

"It is remarkable to note that casing many thousand feet from the lead plate 15 is pacified. The explanation for this may be that both the acid and the casing are good conductors of electricity, but it is believed that an additional

Dr. Carl F. Prutton

factor is involved, namely, that as soon as one part of the casing becomes pacified, the resistance of that part immediately goes up. This is in harmony with the theory that a film of lead or hydrogen or both is formed on the iron since such a film would present a higher hydrogen over-voltage and likewise cause a high resistance to develop. This would increase the current density adjacent other parts of the well. A film would tend to form wherever it did not already exist and once formed would tend to cause the current to flow from the acid to the casing somewhere else which in turn would tend to cause the formation of a film there, and so on, every part of the casing being protected as soon as that part is contacted by the acid."

Now, as I understand your criticism of this paragraph, you do not believe that the forces considered or involved would permit the current effect to reach down the well or down the pipe, is that right? A. It is my contention from theoretical grounds and from the results of the tests that we have made that that action does not occur down to great distances into the tubing.

Q. First with reference to the results of the tests that you have performed, have you examined those tests as to their possible range of error so that you could tell us within what permissible range an effect of the type called for by Mr. Menaul in the patent might have been present in your tests and not been detected? A. It is my belief as a result of the tests that there was absolutely no electrolytic protection due to the lead plate and the hypothesis of the method given in this patent to describe what was claimed to have taken place.

Q. Don't you care to answer my question? A. I can answer it, if you would be very specific as to exactly what you want.

Q. Well, just read—do you want the question read again, and you ask me anything about it you don't understand. A. Let us have it.

(Question re-read.)

A. As I recall, I made the statement that the ac-

Dr. Carl F. Prutton

curacy of our tests was possibly somewhere in the range of variation of 50 or 70 grams of iron in a test. Now, the fact that in our blank runs we got about 1000 grams of iron dissolving and in these tests with the inhibitors added and in the tests with the inhibitors present the Menaul patent contemplated, we got substantially the same figures. That is the basis on which I decide the electrical connection had no effect.

Q. That isn't an answer to my question. A. That is as close as I can come to answering your question.

Q. You are able to take your own work and from your work report a possible range of error, is that correct? A. Why, I think that is correct, but I can't give you an exact figure. It is 9.1% or 9.2%.

Q. Isn't it true on its face it is not any more accurate than within 20%? A. It all depends on the way you look at it. You are looking at it from the bottom up and I am looking at it from the top down.

Q. If it is accurate only in 20%, the possible percentage of reduction in corrosion, this Menaul effect might exist and not be detectable in your test within what range? A. You mean in reduction of corrosiveness?

Q. In per cents of reduction of corrosion, if your work isn't accurate below 20%. A. It is more accurate than 20%.

Q. Let's assume it isn't. A. Why assume that? I claim it is within 5%. I think it is closer to 5% on the reduction of corrosiveness. It isn't exactly 8 or 10. It is somewhere around 10%—5 to 8, and 5 to 8 is probably closer.

Q. Will you look at your tables, PX-187 and 188 and compare run 2-E, PX-187, with 1-N on table PX-188, and 1-M on that table? What is the percentage of error between those two tests? A. In the first place, the oil well tubing was entirely different in the runs. You have to compare the ones and twos with the same number; you can't do it otherwise with the tubing; you can't cross-compare for the tubings.

Dr. Carl F. Prutton

Q. You have averaged the runs up there for 100% corrosiveness, haven't you, in both tables? A. That is one of those average of averages that is approximate but not too good. I have stated between oil well tubing you get a difference of 20% and that means between the two sets of tubing you can't cross-compare. You have to compare one to the other—you have to compare within the one set, and then you compare No. 1's with No. 2's.

Q. Does that mean—within what range could these findings of yours differ within the results that you could get from different oil well tubings, or different lengths or combinations of oil well tubings? A. I have said that the rate of corrosion of one length of oil well tubing with any acid might be 20 per cent different than the results of another length, and that is why we used the same tubes in a series of tests; you have got to compare the ones marked No. 1, with each other; and the ones marked No. 2 with each other.

Q. What is comparable in your tests then—you should not compare the No. 1 runs with the No. 2 runs? A. No.

Q. They should not be compared? A. There the difference might be 20 per cent between those.

Q. You have got to compare the No. 1's with the No. 1's? A. Yes.

Q. You haven't got any No. 2 runs with the same amounts of materials present, for comparison as to their accuracy? A. Do you mean in these—oh, none of the Menaul patent. We have got two 1's and two 2's, but you mean any test where they ran the synthetic—

Q. I mean, in the Menaul— A. (Interrupting): Here are two 1's and two 2's (indicating).

Q. Well, they have different amounts of material? A. Not a great deal.

Q. Have they got enough to account for the difference in the results? A. Not much. I don't think you would get a great deal of difference between the concentrations that you have there (indicating).

Q. How do you know that you would not? A. I don't

Dr. Carl F. Prutton

know, but with that little difference in copper, I would expect it to explain some slight difference here (indicating).

The Court: Let me ask you this, doctor. I was taking a tubing X and tubing Y, and you make up two different compounds of acid and we will call one of those A and we will call another one B. Because one of them—they will all have hydrochloric, both A and B have got hydrochloric in them, and both A and B have got copper, but we have shifted different amounts; and they have both got lead, but we have shifted so that A and B, while they contain the same three elements, they don't contain them in the same proportion. Now, you have got X and you have got Y, two different commercial pieces of tubing. Now, if I apply A to X and Y, and I find that, we will say, X is consumed faster than Y, does it follow that if I apply B to X and Y that X will go faster than Y, or are there some combinations upon which you will get the reverse in the consumption? A. It is my recollection from our data that there are no exceptions to that rule, that you will always get the relative positions. Fairly close. Now, the differences that are being discussed here between 4.3 in test run 1-M, and in run 1-N, 3.25 parts per million of copper, can explain any differences between those two, due to that difference in copper. We have shown when it gets up near 4 it sort of flattens out, that is, that the curve is flattening out, and that the difference we would expect from that is not very great; it might amount to a couple of per cent here, and I am willing to admit that. I am willing to admit these numbers are off four or five units, and I have said there could be a five to eight per cent variation in our test results.

By Mr. Lyon:

Q. Will you explain the difference between run 2-E and run 2-B on the other exhibit, PX-187? What is the per cent of difference there between those two? A. The percentage of difference is from $66\frac{1}{2}$ to 89.1. The difference is 22.6 per cent.

Q. Now, how do you account for that? A. Well, this

Dr. Carl F. Patton

particular one contains .73 parts per million more copper and it is down lower in the range where the effect of copper cutting off seven-tenths of a part per million makes a greater variation, and that would account for some of this difference.

Q. How much? A. I don't know.

Q. Well, now, what is the per cent of error, do you know, whether it is actual error, in comparing those two runs? A. No, I don't know. It would cut back the difference somewhat, probably 15 points, or something like that, in error.

The Court: Do you think if you had analyzed these—that gets back to a question I had previously—and I suppose there are so many different comparisons that you haven't analyzed that I could find some new ones, but this is the same question. Suppose before you analyzed 2-B, that combination, made that test, and before you had made the 2-E, how close do you think you could have come to telling what the percentage of reduction in corrosiveness would be on 2-B, and how near do you think you could have come to telling how close it would be on the other? A. I think run 2-E is possibly one, and the comparison there is possibly one that shows the greatest variation in the series between those two.

The Court: You actually ran this and you are giving me the actual figures? A. I would think you could tell within five to ten points, which is about the figure that I gave you before. Now, I might miss it a little greater than that, but I don't think so.

The Court: You don't think you would have gone lower on 2-B, you don't think you would have guessed lower than 60, or higher than 70 then on that. You think you would have gotten it that close? A. I think so.

The Court: And you think on 2-E you wouldn't have gone that far? A. I wouldn't have gone that high, because that is a little higher inhibition than the rest of the figures would indicate would come. I think that is a little higher inhibition. That is up in the upper end of the

Dr. Carl F. Prutton

thing. I would cut back five to ten points on that, and call it 70 to 80 or 80 to 89, somewhere in there.

Mr. Lyon: I still want to talk about comparing 2-E with run 1-M.

The Court: All right.

Mr. Lyon: You tell me that is a different pipe? A. Yes.

Q. You have figured the particular pipe for determining percentage of corrosion on PX-188 for run 1-M as against the pipe that was run and called that 100 per cent, haven't you, or you have averaged it out, the difference in those two pipes? A. Yes.

Q. How can you account for the difference between 66.6 per cent reduction in corrosiveness for run 1-M where you have 4.33 parts per million of copper, and the results of run 2-E which we have just been discussing, where with a less amount of copper you have 89.1 per cent reduction? A. Just in the nature of the tubing. That is the only explanation I could give you. It is different tubing.

The Court: We have taken the same acid in each? A. Substantially.

The Court: You have taken the amount you would eat 100 per cent to start it with? A. Yes.

The Court: Well, then, it seems as though that—you have already accounted for all the differences in your tubing right there, in that difference in the 100 per cent? A. No.

The Court: I take it one would eat more than the other? A. It wouldn't account for all the difference. It would account for half the difference here. If your rates of attack are known for two sets of tubing and average them, you are half way off.

By Mr. Lyon:

Q. Did you do this, Doctor, or did somebody else inflict it on you, this average of averages you have got in these tables? A. I believe somebody else inflicted it on me. I don't remember. I think the field of comparison is on one side of the tubing and to simplify the thing it was thrown together.

Dr. Carl F. Prutton

The Court: Well, then, that is the only average of averages, that top line? A. The top one. The rest are individual, and we are comparing an average of averages of attack on these blanks.

The Court: For the purpose of getting at what I was asking you about we should have that performed with the same acid in both cases, and take what they eat as 100 per cent? A. Yes.

The Court: Isn't that right? Then we would get at what I am talking about. A. In one set of tubing we got about 1000 grams and the other set about 800, and there was 20 per cent difference between the two sets of tubing, and so what we have done at the top figure, we have averaged up those two rates of plain acid and to compare the individuals and it is not a valid comparison and produces some little difference.

The Court: We can't get at what you are getting at at all? A. The whole question is entirely an academic one in that we are showing these acids are 60 to 80 per cent inhibited, plus or minus 10 per cent, and that is the story, and to argue on differences of 5 to 8 per cent is simply wasting time.

Mr. Lyon: If it is plus or minus, if these results are plus or minus 10 per cent we will say— A. (Interrupting): No, I wouldn't say that.

Q. I thought you did. A. I said a range of 10 per cent. All of these acids are different. All lie within 20 per cent outside range of inhibition, and they are all very highly inhibited.

Q. Well, your statement is, as I understand it, that your tests with the Menaul tank system, which you have already described, establish that there is no effect of connecting the tubing to the tank, unless it be within the limits of error of the tests that we have been talking about, is that correct? A. The limits of error I hadn't fixed exactly.

Q. You haven't fixed them? A. I haven't fixed them exactly, and there is no effect of the Menaul process on the portion of the tubing.

Dr. Carl F. Prutton

Q. Now, you have stated that, on a theoretical basis, current cannot get down the pipe, or get the acid down the pipe? A. I say, the probability that it is going to climb down that acid through a tremendously high resistance, when it has got other and a lot easier ways to go, I say the probability is so remote, and we find such a small amount of current flowing between the pipe and the tank, that most of that current undoubtedly took the easy way, and the minute amount, a trillionth of an ampere might have gone down to the bottom of the well, but I cannot tell for sure that any amount did that was effective to do anything.

Q. This is purely a matter of opinion as to how much of that current gets down? A. It is purely a matter of opinion, based upon a knowledge of the flow of electricity in certain circuits, and electrochemistry, and an agreement with the results of these tests which we have run.

Q. Isn't the resistance of the acid low enough so that theoretically the current could get down appreciably down the well, even 5000 feet, assuming that the formation of the film on the walls proceeds as the acid goes down? A. That question was asked by Judge Tuttle, in which he questioned the relative conductivity of the metal and the acid, and I gave him the figure, I said that the acid was not as conductive as the metal. I gave him a figure, but I guessed at it. I have looked that up, and instead of the metal being 5000 times as conductive, it is 100,000 times as conductive as the acid.

Q. Where did you find that? A. Those figures are from the handbook.

Q. Will you just get your handbook and tell us what the resistivity of hydrochloric acid is, 15 per cent? A. The reason I could not make any certain calculation of this is that in talking of the resistance of metal, we used specific resistance. In talking about solutions for theoretical consideration, we talked about equivalent conductance. You cannot convert one into the other—to convert one into the other is a difficult thing to do so that it can give you an exact figure. This is the Handbook of Chemistry and

Dr. Carl F. Prutton

Physics, Twenty-Third Edition, and the equivalent conductance, page 1529, the equivalent conductance of aqueous solution of hydrochloric acid is given as varying in different concentrations of solutions from—a very dilute solution of 379, and a one-tenth normal solution of 350. And from that you can calculate out that the specific resistance of hydrochloric acid, if you take a centimeter cube of hydrochloric acid and apply a potential of one volt across two opposite parallel faces, when you have a resistance of one ohm, a current of one ampere will flow, and that is about the resistance of this hydrochloric acid. It is very close to one ohm.

Now, if you take a cubic centimeter of steel, on page 1531 of this book, steel is given as varying, different kinds of steel, but here is one steel, 10.4×10^{-6} ohms centimeters. That is the resistivity of it. In other words, 10×10^{-6} is 10^{-5} or $1/100,000$. Its resistance is but $1/100,000$ of an ohm for such a cube of steel. And a cube of hydrochloric acid has a resistance of one ohm. That is the ratio of the two.

Now, in a well there is a bigger cross-section of hydrochloric acid than there is of metal and it becomes difficult to calculate the exact ratio of conductance.

Q. Would you think that the resistance through this 5,000 feet of hydrochloric acid, fifteen per cent, that the value of, say, 4,000 ohms was about right? A. You have to know the diameter of the tube and everything else?

Q. Two and a half inch internal diameter oil well tubing. A. Well, let's see, two and a half inches would be about—how long a tubing was it again?

Q. We have been talking about 5,000. We might as well see if the current will get down there. A. All right. I will figure this out.

Mr. Lyon: If Your Honor please, aren't we entitled to look at the books recording the actual experiments to which the witness is referring? I asked him to produce them. Who has got the books? A. Right over there. Mr. Lightfoot, have you got those two books? Give them to Mr. Lyon.

Dr. Carl F. Prutton

Mr. Lyon: Now, we were trying to figure the resistivity of the acid down—what the total resistance would be in ohms for 5000 feet of acid in a $2\frac{1}{2}$ inch bore? A. You gave a figure of 4000. I came closer to 5000.

Q. It is somewhere between 4000 and 5000 ohms? A. Yes.

Q. Now, did you determine what the available voltage is, effective voltage is that is created in the system in the Menaul type of tank? A. Yes, I have those figures.

Q. About the order of one-tenth of a volt? A. An average of a couple hundredths of a volt.

Q. What is the figure in the Menaul patent, without taking the time to look it up? A. I have seen figures of 35/100ths in this.

Mr. Owen: I would like to have you refer to your notes, Doctor, and give the exact figures. A. I will give the exact figures. Do you know where the voltage is mentioned in the Menaul patent? I can't pick it out right offhand.

Q. You start in and give us the voltages that you found and I will see if I can find the voltage in the Menaul patent. A. All right. Should I read these figures?

Q. Yes, if you have them. A. When the tank was full in run 1-N the millivolt difference between the tank, which was at the start of the test, the millivolt difference in potential between the tank and the pipe was zero, and the microamperes—

The Court: Tell me what that means. A. That means the difference in voltage. You put an accurate voltmeter between the two and there was no potential difference between the tank and tube and there was no current flowing at the start of the test. When the acid had fallen down from 40 inches deep in the tank to $34\frac{1}{8}$ th inches deep, in other words, when about one-sixth of the acid had gone through, the millivoltage, the voltage between the tank and tube was 1.2 millivolts. That is .0012 volts. And the tank was negative. And the micro-amperes that was flowing at the time was $2\frac{1}{2}$.

Dr. Carl F. Prutton

When it was $26\frac{1}{2}$ inches— $28\frac{1}{2}$ inches of acid left in the tank—I can't make that number out. It may be 26 or 28. It is not typed very clearly, but the tank was about one-third empty at the time, there was 1.8 millivolts difference in potential between the tank and the tube. The tank was negative, and 5 micro-amperes was flowing through the electrical wire, 5 micro-amperes would be five millionths of an ampere.

The Court: What was it in millionths? A. Micro.

The Court: Five in a million? A. Yes.

Q. You were telling about this wire now? A. Yes.

Q. What I am interested in is the voltage that is set up in this circuit in the tank? A. You mean inside of the tank?

Q. Yes, between the lead plate and the acid. A. I couldn't make any measurements there.

Q. You didn't make any? A. We couldn't.

Q. You could have. A. How? I would like to know. I couldn't figure it out myself. Maybe you can tell me.

Q. I should have asked you, couldn't you? A. Not with my knowledge.

Q. There is no way of determining the available voltage in this galvanic cell that is created in this tank? A. Well, I entered the work in this lawsuit with the idea that we were going to see whether this tank with the lead in it inhibited the corrosion of the tubing. I was not interested in the tank, so I didn't even give it much thought, but just offhand I couldn't tell you how exactly to measure that in that peculiar shaped fashion.

Q. The point is that you did not measure it? A. I did not measure it.

The Court: When you measured the wire, that does not measure the other current? A. It does. It absolutely measures the current.

The Court: It is your theory that it would measure it, and it is your theory that it would not? A. May I state this here, we measured the amount of current that flowed into the copper wire from the tube to the tank. Now, that

Dr. Carl F. Prutton

is the current that had to go down in the acid, in the tube, and then come back through the tube back to the tank, and that is what we were interested in. He asked me whether we measured the current that flowed through the lead plate. We didn't do that.

The Court: Your theory is that that goes from the lead to the iron, through the copper down into the tubing and back through the acid? A. No.

Mr. Lyon: That is just wrong if that is his theory. A. It is just the reverse. It goes from the lead to the—in order to do any protecting, it would have to go from the lead up through the acid, inside of that tube all the way down to the bottom of the well, back through the well tubing and back into the tank. In that circuit we put a microammeter and measured how much current was flowing in the tubing, and it measured the amount of current that went down to the bottom of the well.

The Court: I have been misstating everybody's theory. I had—all I did was make the current flow in the wrong way. Of course, it has got to flow in one way to make it deposit on the lead. A. Yes, Mr. Lyon, with our theory.

Mr. Lyon: You are in general agreement? A. But the question you have in mind is did we measure the amount of current that went from the lead plate to the walls of the steel tank. That is the question.

Q. Through the acid. A. Through the acid to the walls of the steel tank. And the answer is, we did not.

Q. As a matter of fact, just to clear the matter up about this current coming back up from the bottom of the well through the oil well pipe, in effect the system, the tank and the pipe are both grounded, are they not? A. Yes.

Q. So you have got a circuit from the— A. (interposing): Did you say the pipe and the tank were grounded?

Q. Yes. A. The tank is not grounded.

Q. It could be. A. You have it on rubber tires on an automobile.

Q. Connecting to the pipe is the same effect as grounding the tank, isn't it? A. It is connected through another electrode to the ground.

Dr. Carl F. Prutton

Q. Yes. A. But that is not the same as grounding itself.

Q. I understand. But when this tank is connected by this cable to the pipe you are accomplishing what you would accomplish if you grounded the tank? A. Yes.

Q. And the pipe is grounded? A. Yes.

Q. At the well, is it not? A. Yes.

Q. So that the path of current is from the lead plate—is from the ground through the lead plate, through the acid, to the tank, to whatever metal you are going to protect, isn't that it? A. From the lead plate through the acid to the tubing.

Q. Yes, to the ground. A. No. Some of it comes back.

Q. It is grounded, though. A. And the amount, you can't predict or calculate the amount.

Q. Now, that is what I am getting at.

The Court: Then you only got part of it when you measured your copper wire; is that right? A. The amount is, which I would expect to flow to the ground, is not a great deal. The voltages that we have here are indicative of the driving force tending to drive current from the tank with the lead sheet in it, through the acid into the tube and into the ground, or, it is rather—

Mr. Lyon (interposing): Well, now, suppose we are interested in whether or not we are getting any protection at 5,000 feet down the well. Are you able to state what the magnitude of potential would be or would have to be to set up down there in order to polarize? A. I can't tell you that.

Q. Well, you can't actually prove, can you, that there is not sufficient current there in this system? Theoretically in your opinion there isn't but you can't prove your point. A. The potentials that we have measured, the currents we have measured are all so minute, the patent talks about $\frac{3}{10}$ of a volt, or $\frac{2}{10}$ or $\frac{1}{10}$, and here we find one thousandth of a volt to drive current down the acid, and it is impossible, in my opinion, that any much greater amount

Dr. Carl F. Prutton

of current than what we measured went down that well bore. I don't know what the patent said. I am just saying it indicates an appreciable voltage, but your advertising literature said 35/100 of a volt. It doesn't—

Q. (interposing): The patent doesn't say anything about tenths of a volt. A. It doesn't!

Q. I can't find it. A. I assume it said an appreciable voltage.

Q. It says in an ordinary cell the voltage causing the current which is required for polarization is very low, being about 100 millivolts. He says that at page — A. (interposing): That is 1/10 of a volt. I think that is where I got the idea of 1/10 of a volt. When measured, the voltage was one thousandth of a volt.

The Court: Where did you measure that? A. Between the tank and the tube.

The Court: Well, in the copper wire there? A. The copper wire was temporarily—put this across the ends of the copper wire, we put a millivoltmeter and it measures the difference in potential that occurs across there.

The Court: Where was it you got that two and a half to five? A. Two and a half microamperes flowing through the copper wire. The quantity of electricity flowing.

The Court: And what is the one and— A. (interposing): Millivolts?

The Court: Yes. A. That is one thousandth of a volt. That is the electrical pressure that is tending to drive current from this lead plate down through the acid in the tubing, down to the bottom of the well, that one thousandth of one volt.

Mr. Lyon: Now, you have said you can't tell us how much electrical pressure or potential would be required down the well in order to polarize it, the pipe. Is that because you haven't determined it or is it because it could not be determined? A. I can tell you that in the electrolytic protection of pipe lines that they have to use .3 volts, and that is standard practice, and I can give you many references to it that are well known and accepted. If you

Dr. Carl F. Prutton

get below .3 volts they get imperfect protection, and the amount of current that they use to accomplish that protection is a considerable amount. These figures are negligible compared to those figures actually used in that electrolytic protection.

Q. I am not asking you that. If you would just follow my questions, it is somewhat difficult for me to phrase them in this technical subject, I think we could make better progress. I asked you whether or not the fact that you answer that you did not know what potential or driving force was necessary to polarize the pipe at 5,000 feet was because you hadn't ascertained it or because it could not be ascertained? A. We did not ascertain that.

Q. Could it be ascertained? A. I don't think it could be easily ascertained. You could, in a laboratory, set up some sort of apparatus, but to try to astrabalate from that down to the bottom of this well, with the complex electrical conditions that you would have to figure, would be no practical figures whatsoever, and I made no attempt whatsoever to do that, and we feel that these figures being so minute down to the millionths of an ampere, and thousandths of a volt, are so negligible—if you would take that rail out here in front of the lawn you would find one thousandth of a volt difference between the different ends of it, and there is not supposed to be any electricity flowing in it, and the amount is so negligible that as far as I am concerned there is no electrical flow there.

Q. Well, Doctor, as a matter of fact, even that order of pressure or potential, say one thousandth of a volt, is not enough to accomplish the polarization, you say? A. I would state that it would be my opinion that it would not be anywhere near enough to establish polarization, but I can't tell you on the basis of any exact tests.

Q. Well, then, your testimony that there could be no current flowing down the acid in the well sufficient to produce a polarization anywhere down the well, is purely a matter of opinion and speculative opinion at that, not one that you are able to prove? A. No, it is on the basis of

Dr. Carl F. Prutton

my knowledge of electro-chemistry of electric circuits and the results of these tests when made with oil well tubing that showed if you had that pipe polarized in the tests we made, polarized sufficiently to do any good, we would have a sufficient amount of iron dissolved but we got no noticeable difference.

Q. Subject to the limits in your error, of course? A. I have stated the limits in error.

Q. Now, are you testifying that the current wouldn't be sufficient to cause any polarization in 5000 feet? Are you of the same opinion the same difference would go all down to the ground? A. I would say within 50 feet of the connection any polarization you get would be negligible. I might admit it within a few feet of the wire and in the tank I have admitted it definitely, but even that is stretching my imagination considerably.

Q. Let's talk about the tank a little bit. In the first place, would it make any difference, if so, tell us, if a copper plate was substituted for the lead plate that is bonded in this tank? A. If you put a copper plate in place of the lead plate, I don't know what it would do. I think that your copper would dissolve, some of it would plate out upon the iron, and whether it would plate out in the correct form to do inhibition, I don't know.

Q. I thought you told me a little while ago there wasn't anything to Menaul's announced discovery of the shifting in the electromotive series of lead and copper in hydrochloric acid that any school boy or high school graduate could not predict from calculation. A. Offhand, on copper I can't tell you. You have to get solubilities of copper, hydrochloric acid, coefficients, and with that information it would be possible to go through and make calculations.

Q. Don't you think the first man that had ingenuity or sense enough to do that in the case of lead was entitled to discovery? A. I would say he is entitled to discovery if he had patented his discovery, but he patented the use

Dr. Carl F. Prutton

in an oil well. He discovered you could protect the tank with a lead sheet. He casually mentions it in the patent.

Q. Casually? Figure 5 shows a tank. A. Well, that method is treating an oil well.

Q. Well, Mr. Menaul was working with a company engaged only in the treating of the oil well business. A. May I read a part of the patent—"A method and apparatus for handling acidic solutions." The examples, there is only one case where it shows the tank alone with the lead sheet. There are three, four illustrations showing methods of using it in oil wells.

Q. Different, aren't they? A. Somewhat different. But it implies in the description, the specification is readily practical on protecting the tubing and casing and parts of the oil well.

Q. What do you think he should have patented as a discovery? A. A storage tank with a sheet of lead. I think he should be given a patent on that.

Q. You do? A. Yes. I think that had some little element of invention on that. I don't want to qualify as a patent expert.

Q. We are not suing on it so you don't have to worry about that. What would happen if you substituted a copper sheet for a lead sheet? Why can't you tell us that? A. Because I don't have the data needed to give you that.

Q. You think you could calculate it? A. Yes.

Q. Sure? A. I believe so.

Q. Do you know what might happen? A. No.

Q. What do you think might happen if you put a copper sheet in that instead of a lead plate? A. I can't tell you.

Q. What do you think happens in this system of the defendants to the tanks if the bond disappears between the lead plate and the bottom of the tank? A. I would believe if the bond disappears that you would get less lead and copper going into solution, and that the tank, because you would not have—you would have a lower inhibition due to lead and copper in solution, and you would have elimi-

Dr. Carl F. Prutton

nated this small amount of electrolytic protection, but you would get a more rapid attack on the tank, and the tank would dissolve.

Q. How fast do you think, comparatively? A. I couldn't tell you that. That is an impossible question to answer.

Q. Why not? You have made all of these measurements? You have studied this system? Why can't you tell us how long an average tank would last with this system? A. That is like asking a geographer who has made a study of Michigan to tell you how China is put together. He knows the general hills, the valleys and the mountains, and he knows the contour of Michigan, but that does not mean that he can tell you about China.

Q. Let us say that the tank is inhibited 60 per cent in one case, and 99½ per cent in the other. What difference would there be in how long they would last? A. If those figures were—well, it would mean eight times as long as the other.

Q. Now, as a matter of fact, have you inquired at all as to how long these defendant's tanks last? A. I have not been interested in how long they last.

Q. Would you think it probable that the defendant is still using the same tanks that it started with in Michigan in 1935? A. I think it would be highly improbable, from our tests, that they are using the same tanks, if they only polarized them once.

Q. Do you think that it would be necessary that they be polarized more than once? A. Yes, that is my opinion.

Q. Are you quite sure of that? A. No, I just say it is my general—I can't tell you exactly, but in our tests we had so much iron dissolving from the tanks, the Menaul type of tank, which we polarized once, that apparently that protective coating of the lead that you plated on when you polarized it was taken off, and it was not quite as good a job.

Q. Maybe you didn't do a very good polarizing job.
A. Well, we bought a brand new automobile portable stor-

Dr. Carl F. Prutton

age battery, about 100 amperes an hour capacity, and put the thing in and let it go overnight, just the way the defendant did in polarizing their tanks and we used one of these little tanks, instead of using 1000 gallon capacity tank where the surface would be greater.

Q. I won't ask you to be responsible for my statement that the tanks are still in use here, the original tanks, and there are no facilities for polarizing here when they are made at Duncan. I won't ask you to be responsible for that. Can you estimate how long a tank would last in ordinary service if this lead plate was not bonded to the bottom of the tank?

Mr. Wiles: Mr. Lyon, how frequently is the witness to assume the tank is used, how many hours a week?

Mr. Lyon: How many hours do you think it would last with acid in it? A. I couldn't tell you that.

Q. You couldn't? A. No, I couldn't tell you that.

Q. Now, let me see something about these tests you have run. You took the freshly polarized tank and conducted your check tests in it with commercial acid first? A. We took the freshly polarized tank and washed it out thoroughly, and then we prepared the 15 per cent commercial acid.

Q. You washed the tank? A. Sure.

Q. Did you do any scrubbing with this wire brush that you were talking about? A. Absolutely not.

Q. You didn't? A. We might take that polarized lining off if we did.

Q. And you ran that acid down this tubing for testing? A. Yes. Then we put the acid into this Menaul polarized tank and stirred it every fifteen minutes with a big, heavy glass stirring rod about four feet long, by hand, without scraping the sides, for the six hours, and then we started to run the acid through.

Q. That took about three and a half hours? A. Around three hours.

Q. And that was what you called Test No. 1? A. I don't remember.

Dr. Carl F. Prutton

Q. 1-A. I was trying to get your system there. The one relates to the tubing? A. 1 is the tubing system.

Q. A is the test with the commercial acid without anything in it? A. I don't know the numbers there. I can't tell you.

Q. After you got through with that test what did you do? A. You mean after the Mēnaul test?

Q. Let us go back to the tests you made at the beginning when you just used the crock? A. Yes.

Q. The first test you made? A. Was commercial acid through the tube.

Q. Then what did you do? A. Then commercial acid in the Mēnaul tank.

Q. How long did you leave that commercial acid in that tubing uninhibited in that first test? A. In the tubing?

Q. Yes. A. I didn't leave it at all.

Q. I mean it took three hours to go through, didn't it? How much did you put through there? A. We put 200 gallons through in each test.

Q. You put it in at the rate of a gallon a minute and took it out at the bottom at that same rate? A. Yes.

Q. That took how many hours? A. Three hours.

Q. Now, then, when you got through with that test, what did you do next? A. Then we ran with the wire disconnected.

Q. No, I haven't got any tank in this. I have got the crock. And you are just running the commercial acid. A. We took the commercial acid in the crock, adjusted the temperature, then ran it through the tubing system. That was our blank. Just commercial acid through the tubing.

Q. Yes. A. That is one test out of the way. We got 1000 grams of iron. The next test we took the 15 per cent commercial acid in the stoneware crock, blending it up to the right strength and temperature. We ran that through a Pyrex tube down into this Mēnaul tank which was sitting somewhat below to the side of it and kept it in the Mēnaul tank for six hours, during which we gave this occasional stirring, and then at the end of that six hours in the

Dr. Carl F. Prutton

Menaul tank with the wire connected to the tubing, we transported at the rate of one gallon a minute through that tubing, down and out the sewer.

Q. All right. Was that the same tubing you used in testing for the commercial acid? A. That is what the 1 refers to. The 1 refers to the same tubing which was used in the commercial acid, the Menaul acid and so on.

Q. How many different tests did you make with this No. 1 tubing altogether? A. I would have to look through our records, but I think that there was several. I think there is one or two tests, maybe not even that number, that were made on the No. 1 series of tubing that are not shown on these charts.

Q. In all these tests you have the acid in there about three hours? A. The time of running it through the actual tubing system was three hours and 180 gallons was run through.

Q. How many tests did you make with this tubing altogether? A. On one set of tubing?

Q. Yes. A. About five or six.

Q. How many of those tests were with raw commercial acid? A. Two.

Q. Now, did you do anything to the tubing between those tests? A. Yes.

Q. What did you do? A. We took the tubing out, we washed it out and filled it with 15 per cent commercial hydrochloric acid, let it stand for an hour, dumped that out, washed them out again, put solvent through to dry it, and then we reamed the tubes out with this stiff, hard wire brush and put a burnished surface on the inside of the tube, and took all loose metal out, and we got a condition more or less reproductive of the surface of the inside of the tubing.

Q. How thick was this tubing, ordinary oil well thickness? A. Well, it was 2.4 pounds per foot of length and it was about $\frac{1}{8}$ th of an inch thick.

Q. Am I correct that this tubing got—was subjected to a good deal of action from hydrochloric acid? A. Not a great deal.

Dr. Carl F. Prutton

Q. It was not? A. We ran two preparations.

Q. That would be seven hours? A. Two preparations, that is six hours.

Q. Six hours. Now, let us talk about that. Did you find the tube was still in good shape when you got through with those two runs? A. Well, it was pitted after those runs.

Q. Badly? A. It was definitely pitted in that time and I couldn't tell how badly, but at the couplings the threads were pretty well chewed up.

Q. Did you have to put new threads on? A. No, we simply tightened them up a little more.

Q. As a matter of fact, your tube was in good enough shape so that you could start out and still use it, couldn't you, after all these tests? A. But these tests have no relation—

Q. I am not asking you to argue. A. To perform this test and put in service these—

Q. I am not asking you to argue about anything. The tubing was still in good enough shape to make more tests?

A. I would say that it is not.

Q. It is not? A. Yes.

Q. Isn't that it? A. I would say that we were getting right close to the end. There are threads right on the lengths of tubing, and the acid has eaten into the collars. The last times we made the tests, there would be a drop of acid coming out of it, and we couldn't tighten it up.

Q. After your first test, the first time that you ran the raw acid through the tubing, it was still in good enough shape to continue to make four or five tests, isn't that correct? You did make four or five? A. Well, we did, sure. We felt it was good enough for that purpose.

Q. You say it was pitted. Did you get all of those pittings out of there by your treatment? A. I believe we did. The surface, when we examined the tubes after drawing the stiff wire brush through, was quite highly burnished; it wasn't exactly smooth, but most of the pitted effects had not been completely smoothed out, but at least

Dr. Carl F. Prutton

somewhat smoothed out. We couldn't see in any too great a length in the pipes. We could see in for six or eight inches, possibly look through the whole length, but not to look down into the pits.

Q. How do you know that there were serious pits in there? A. I did not say that there were serious pits in there. I said it was pitted looking. In one run of these Menaul type acids, and inhibited acids, it showed a matte finish that did not have this pitted effect, it was much smoother.

Q. How deep were those pits? A. I couldn't tell you that. We made no attempts to measure it.

Q. You could tell that by just running this wire brush through there? A. We got a substantial number of them out by doing that, and the surface of the tube was, we felt, substantially the same as the surface before, but there may have been some of the pits remaining. I do not know.

Q. Did this tubing get noticeably thinner in all of these tests now that you have made, four, five or six tests of that tubing. A. We only ran two tests for three hours, with a total of 360 gallons of uninhibited acid, and that did most of the corroding, so the actual time was only for six hours, and I don't know just how thick it was left, but if you figure how thick a layer of iron is—well, we took off that tubing in the two uninhibited acid tests, we took off about four pounds of iron.

Q. And how deep was that? A. I think you and Dr. Bartell figured out something on that, a few thousandths of an inch. But we did not take it off uniformly. It was very definitely in the uninhibited acid.

Q. If the corrosion is not going to work uniformly, but is going to work in concentrated areas, what happens to the effectiveness of an inhibitor if it is only, say, what you call fifty per cent inhibited? A. I do not know what kind of an answer you want me to give you to that question.

Q. Well, as you concentrate the corrosive effect of your acid you are concentrating any residual corrosive effect of your acid, are you not? A. As you concentrate the acid?

Dr. Carl F. Prutton

Q. The action of the acid; assume that the acid will get in particular areas more than an average over the whole pipe? A. The general consensus of the—the result that I have seen by observation of these laboratory tests is that when you use uninhibited acid, you get this pot-marked or pitted effect; and when you use inhibited acid, you get a smoother surface not nearly as much eaten away.

Q. But that is not what I am asking you at all? A. No?

Q. We have been talking about this on the basis of trying to get an effect of this corrosion, on this uniform effect over the area of the metal that the acid is acting on, and you suggested that they ought to start this out as expending itself more violently in particular areas. A. Well, I have explained here in discussing the theory of corrosion how corrosion usually, unless it is inhibited, does do this pitting action. It attacks these areas that are anodic and therefore you are to expect pitting at these high potential places. When you put inhibitor in that, you have a smoothing-off effect.

Q. If that is true and your acid is going to act that way you are not going to get much good out of 30, 40, 50% reduction in corrosion, are you? Just think that over. A. I think you would. I think it would be very effective as compared with the uninhibited acid; you get a less pitting.

Q. Would you? With only a 50% reduction in corrosion? A. Yes.

Q. If acid is going to concentrate at a certain point—
A. (Witness interposing): These acids ran up to 60 or 80, the ones with lead and copper, and they gave a smooth finish.

Q. Well, if you are in danger of having pitting, can you stand for an acid that is 10 or 20 times as corrosive, as effectively, say, so far as 99% inhibited acid is concerned. A. I would hate to answer that question because it involves too many guesses on my part. I would think that it would be very much superior, very much superior than the raw acid. The raw acid, particularly if used with inhibition to

Dr. Carl F. Prutton

get this 50% effect, a type of inhibitor that cooperates and gets an added effect of a small amount of oil left in the tube so you might start out with 60 to 80% inhibited content, and that same amount left in the tube picks up to 80 or 90%, you get very good results.

Q. The judge suggested a while ago putting something in this acid so it won't burn your hands. Does 15% hydrochloric acid burn your hands very quickly? A. It doesn't burn my hands. I don't know, someone less accustomed—

Q. (Mr. Lyon interposing): Let's take a sulphuric acid. A. 15% sulphuric?

Q. Let's take an acid that would burn. A. It might.

Q. Let's take a normal sulphuric acid; that will burn your hands fairly quickly, would it not? A. It will burn fairly quickly, yes.

Q. It will burn so quickly just diluting it 50% or adding the inhibitor the judge had in mind earlier in the day in the case wouldn't do you much good, would it? A. What do you mean? Adding 50% water? Cutting its strength in half wouldn't do much good.

Q. I can take my hands and put it in commercial sulphuric? Well, if I have the wrong example—what I am getting at is this: Suppose you had an acid that had marked burning effect on your hands, and when you got through cutting it down 50%, that effect, it still would burn your hands very badly. Now, then, if you had a sore on your hand so that the acid could cut it down 50%, that effect, it still would not do you any good at all, would it? A. I don't think the analogy has any relationship. It is just like asking me what would happen if I drank a bottle of sulphuric acid.

Q. All right. You have a lot of figures here about per cent corrosiveness. Tell me how much damage to an oil well pipe, as a practical manner, putting down some 3000 gallons of acid, or commercial hydrochloric acid, at the rate of say 750 gallons an hour, is going to do to that pipe. For how long do you want to put it down there? A. I am

Dr. Carl F. Prutton

going to put it right down, all down at the rate of 750 gallons an hour.

Q. In one hour. A. 750 gallons in the first hour, 750 gallons the second hour, and another 750 gallons in the third hour. Four hours, then?

Q. Yes, 15% hydrochloric acid. A. I can only tell you on the basis of assuming the rate of dissolving the metal is the same.

Mr. Lyon: I don't know.

Q. Do you contend these figures of yours have significance tied to oil wells? A. Yes, I think they do. I can't answer that without figuring it out. I have to assume the rate is the same as here because I have no experience with that.

Q. Do you believe it would be? A. Yes.

Q. Is it true you know of no other tests except pouring it in the tube at the rate of one gallon per minute, taking it out at the rate of a minute? A. That is the test we made.

Q. The only one? A. We made one test, one test which I described and tried to put oil in. We ran a little faster than that at the beginning but as the oil solution came out we decreased.

Q. Why didn't you try the different rates of velocity? A. First, 1 1/4" is the smallest tube available to be purchased; second, stoneware crocks only come in a certain size. We couldn't get more than this 250 gallon crock into the doors of our building. We figured an average acid treatment might be 300. So we put in a 200 gallon crock, 250 gallons—we could put about 200 gallons of acid in it, and if you ran a 1 1/4" pipe 3 hours you get 60%, approximately.

Q. You say something about an average oil well treatment? A. That is more or less hearsay in discussion with Mr. Rebbeck and others.

Q. As a matter of fact, you talked this all over with the Dow men before you ran them. A. Surely, I told you I had.

Q. They told you different ways. A. Yes, and I sug-

Dr. Carl F. Prutton

gested three hours. They didn't mention that. I say I said, let's take three hours, which shows this condition. We did not understand any other condition whatsoever.

Q. You understand 3 hours is the time it takes to acidize a well, to take the acid down the well and out of the pipe? A. I think that is a convenient time. I have heard of times that run over a day, much less than a day—you can't average those things. It would be trying to figure out how long it takes to shoot a duck. It may be a week and it may be a minute. You take the middle. That worked out in this 250 gallon crock which we could buy in Akron, and we started our tests and made those conditions. We made no preliminary tests whatsoever.

Q. What effect do you think it would have on your figures, any of them, if you acidized a well in the same length of time but you put about between 2500 and 3000 gallons of acid through the pipe? A. Well, it would depend on the inside surface of the pipe. Give me a specific case. I can take the average rate of attack in this tubing and figure it out for you.

Q. Do you think the rate of attack would be the same? A. I think very close to it.

Q. How do you know if you haven't tried it? A. Well, this is oil well tubing. We studied the various factors that entered in affecting the rate of attack. The figures we have obtained I think are close to what you have obtained.

Q. Does the amount of agitation have anything to do with the figures? A. I think with agitation you get a higher reduction in corrosiveness.

The Court: You don't mean that, do you? A. Higher percentage reduction in corrosiveness, for the inhibited acid. When you agitated the samples and agitated C. P. acid, the rate is increased, more attack on the steel, more attack of the C. P. acid on the steel.

The Court: The rate of corrosion is— A. (interposing): Yes. That is the C. P. acid. Now, when you take the inhibited acid and agitate it in a piece of steel, the rate

Dr. Carl F. Prutton

is increased, but the ratio of the two, this one, does not increase as much as the uninhibited acid.

The Court: But they each increase in corrosiveness.

A. As they get higher turbulence.

The Court: By agitation. A. That is correct.

The Court: They each decrease in inhibition? A. That is correct.

Mr. Lyon: What about commercial acid? A. Because it is trying to scour off that protective coat on the surface, and keep thereby increasing the rate of attack on the metal.

Q. You have answered as to the C. P. and inhibited. What is the answer on the same point as to the commercial hydrochloric acid? A. The information we have obtained is that the commercial acid we used in our tests is not much different than the C. P. acid, and therefore there is a very low percentage difference in rate of attack.

Q. Is there any difference? A. I said up to 6½ per cent was the maximum, and most of them were zero to one or two.

Q. Well, now, you admitted that agitation is going to make a difference. A. Oh, I think it would; surely.

Q. Then there will be a difference in the amount of agitation and in the kind of agitation where you are pumping at the rate of 750 gallons an hour down a pipe or where you are pumping at the rate of 60 gallons an hour? A. Absolutely there would be a great deal.

Q. And also considerable effect on the acid. How will it affect the amount of reduction in the strength of the acid that issues from the bottom of the pipe? A. With the higher velocities I would anticipate you might get a greater rate of attack on the metal surface, but that the percentage of acid that was spent in going through, if you take a given length of pipe, it would probably be a little lower.

Q. Well, now, wait a minute. A. It would be a little lower.

Q. A little or a lot less. Find out how much difference do you think in the amount of corrosion, compared to your tests, would be made by this different rate of feeding

Dr. Carl F. Prutton

the acid through the pipe? Do you think it would double the corrosiveness or add two hundred per cent to it? A. I don't know. I really don't know. I haven't studied the velocity effects, and I am just—in the laboratory tests we ran without any agitation we got about five or ten per cent less inhibition than we got in running it at a foot per second, but I don't think you could keep on adding ten per cent for every foot per second velocity added, because pretty soon you would be over 100 per cent. I think it tapers off.

Q. You don't know where? A. I don't know where it tapers off; we haven't made any tests.

Q. In other words, is there something about the making of the—or the effect on the strength of the acid that would be brought about by running down 750 gallons of acid in the same length of time you ran down 60? That is a completely different order of magnitude than any differences due to the agitation, you can see that. A. Well, as I said before, if you started out with fifteen per cent acid in a given piece of tubing, and a given length of tubing, and ran that fifteen per cent acid through at the rate of 750 gallons per minute, you would get some reduction in the acidity. What it is I won't say. But if you ran it through at the rate of 250 gallons per minute, you would probably get a greater reduction in acidity, you see.

Q. You don't want to say what the comparative magnitudes of those would be? A. I could figure it out, if you would let me use those figures, the average rate of solution of the pipe.

Q. No. A. I have to have something to start with. I have to have some numbers. I can't express it in terms of acts.

Q. That would be, such a figure, just figuring. A. I can't.

Q. I want to get an answer that adds some facts to the case. Well, now, you were going to, I believe that I indicated I wanted you to tell me even in your tests what the percentage of concentration of the hydrochloric acid was that you recovered in your tests at the bottom of the tub-

Dr. Carl F. Prutton

ing. You say it was fifteen per cent hydrochloric acid at the top. A. Yes.

Q. What was it at the bottom? A. Well, in these tests, of course, which were made in this very short length of tubing as compared to an oil well tubing, the amount of iron that dissolved was about two pounds, a little over that or a little under, so take two pounds. A gallon of hydrochloric acid, if you let it spend itself on iron, will react with just about one pound of iron. One gallon of fifteen per cent hydrochloric acid. And therefore we ran through about 180 gallons of acid and two gallons out of that was expended in attacking the tubing. Now, if we have a tubing 5,000 feet long, we would have fifty times that amount, or fifty times two gallons would be 100 gallons, approximately.

Q. I am not asking that. I am asking what was the actual reduction from fifteen per cent in the actual tests that you made? A. That would be two gallons of 180 were consumed, and that is a little over one per cent, so a little over one per cent of the acid would have been consumed in that short length of tubing. The acid would have fallen off from 15 per cent down to about 14.84.

The Court: You are asking really for a qualitative analysis, I take it. A. We didn't analyze it.

The Court: He figured how much iron he got and how much hydrochloric acid would take that off.

Mr. Lyon: That is satisfactory to me. But it reduces it in the strength.

The Court: I don't know whether there would be a way of making that qualitative or not. A. There would.

The Court: That would be the effect.

Mr. Lyon: Yes.

The Court: I don't know whether it would come out by the same balance or not. A. I think you will admit the method—your men will admit the method of calculation.

Mr. Lyon: I am not asking you that. The difference between the strength of the acid as you put it in at the top of the well, and as you take it out at the bottom, with the raw commercial acid down your pipe, was a difference be-

Dr. Carl F. Prutton

tween 15 per cent and 14.83 per cent. A. As I explained to you the length of tubing was 100 feet long. If you did that to one that was several thousand feet long, you would have twenty, forty, or fifty times that amount of reduction.

Q. I am talking about your tests.

The Court: He wants to know what it was in yours.

A. Fifteen to sixteen hundredths of a per cent. If that is the question.

Q. If you had a long well, the length of the well would be a factor that would vary that, and the rate at which you pumped the acid down the well would be another factor, would it not? A. Well, why vary two variables? Why not stick with one variable? One variable is the length. Let's leave the other variables the same.

Q. If you increase the velocity of the well, that will tend—increase the velocity of the acid, that is the length of time the acid is in the pipe, a given amount, why that has the effect of reducing that difference, doesn't it? A. From all that I could tell you, or what would be, if you keep the figures the same I could tell you exactly or very close your reduction in acidity, which would be very appreciable.

Q. Well, now, I think from your calculations of the loss in 1000 feet of 2-inch tubing, 2½ inch tubing, which you said was 9.3 pounds loss—well, what would you calculate to be the depth of the corrosion of that type? A. 9.3 pounds of iron?

Q. Aren't those the figures that you gave? A. I think that is about right. It wouldn't be very much. It would be this few thousandths of an inch. I can calculate it if you want me to.

Q. It would be in the order of a thousandth of an inch? A. I don't know. It might be three or four. If you figure that it was all uniformly attacked, and there was no pitting—

Q. Just a minute. What percentage of the tubing by weight would that represent? A. I don't think it would represent a great percentage by weight, but it might make a critical effect on the strength of it.

Dr. Carl F. Prutton

Q. Well, that is all I want, what percentage of weight would that be, of what order? A. If you take five thousandths of an inch, and $3/16$ ths, you would have, oh, that would be about $1/30$ th, or, no—about $1/50$ th, something like that.

Q. Oh, let us get it more accurately than that. A. Let us take the—have you got the thickness of the 2-inch tubing that you want me to figure on?

Q. It is 6.4 pounds per foot? A. Well, I can't tell you how thick it is from that. I can't tell you how thick it is.

Q. But you know that 6.4 pounds per foot is 64,000 pounds in 1000 feet—you know that? A. Oh, yes.

Q. And you get 9.3 pounds off of it— A. If the corrosion were uniform, it would be nine sixty-four thousandths of the total weight of the pipe. No, wait a minute. You say it is 6.4 pounds per foot and 1000 feet?

Q. Yes. A. That would be 6400—it would be $9/6400$. Excuse me, it would be $9/6400$.

Q. That is right. Now, do you know anything about the cost of that pipe? A. I know it is pretty good steel, and in some cases they use a steel alloy.

Q. How much a pound does that pipe run, have you any idea? A. I don't know.

Q. If I told you that it is 5 cents a pound, and you say you have lost 9.3 pounds in 1000 feet in taking off this one or two or three thousandths of a foot, that would mean that you have actually lost about 45 cents worth of pipe?

A. No, that is no comparison at all.

Q. By weight it is? A. Well, that is a completely fallacious argument.

Q. Well, I am asking you for the facts, not for the argument, you know. I don't think it changes the case. A. If that was 45 cents worth of pipe you asked me, and I say no.

Q. By weight, if it is 5 cents a pound? A. You don't figure a loss, a financial loss by weight.

Q. I am asking you if that isn't about 45 cents worth of pipe? A. No.

Dr. Carl F. Prutton

Q. By weight, if the pipe is 5 cents a pound? A. I say it is not.

Q. All right. Now, have you got the analysis for the commercial acid that you used? A. Yes.

Q. Did you make different analyses for the different shipments? A. No. We made analyses of the crock acid before each run, you see, to be sure. We did not want to analyze each carboy, so we blended the right mixture for a run and took samples of it and analyzed it to be sure that just before the run we had the right composition, so we have those figures.

Q. You have an average? A. I have figures for each run, with the exception of two runs, and we were using the same acid, the same shipment in those runs that we used in others and the analyses were coming out so uniform that those runs were not made, the analyses by per cent inhibition of each batch was run. That was the real important factor that we had in mind.

Q. Well, now, what I want to know is the amounts of copper, lead and iron in your acids? A. Which run do you want?

Q. If they are different list them for me, if you will? A. Well, run 1-A the iron was 9.3 parts per million, the lead 1.3 and the copper .21. In run 1-AA, 4 parts per million of iron, 1.1 of lead, and .02 of copper. In run 2-A, 9.3 of iron, .9 of lead, .04 of copper. In run 2-C, 6.5 parts per million of iron, .3 of a part per million of lead, .11 parts per million of copper. Run 1-B, 11.2 of iron, .9 of lead, .16 of copper. Run 2-B, 14 parts per million of iron, .4 of lead, and .09 of copper. Run 1-M, 6.6 of iron, .15 of lead and .09 of copper. 1-N, 16.7 of iron, .4 of lead, .09 copper. 2-M, 11.2 of iron, .2 of lead, .16 of copper. 2-N, 8.7 of iron, .5 of lead, and .16 of copper.

The average for the copper is about fifteen hundredths of a part per million. The average for the lead, very roughly around half a part to one part per million, and iron is around maybe eight parts per million. I haven't averaged them. I have given you a general picture and there was very little deviation.

Dr. Carl F. Prutton

Q. That is about one-tenth as much copper as reported in PX-161 for the acid taken from the defendant's storage tanks and about one-twentieth as much lead and about one-fourth as much iron? A. Well, now, what exhibit are you referring to?

Q. PX-161. It is my copy of Dr. Bartell's work? A. This shows .98 in Exhibit PX-161, .98 parts per million of copper and the highest figure we got was .21 in any of these commercial acids.

Q. And the highest figure Dr. Bartell reported was 1.5? A. Yes, and the lead is about ten times or fifteen times as much lead as we had and copper is about five times or so of the acid that we had here.

Q. Now, do you have any knowledge of the amounts of copper and lead and iron that are ordinarily found in hydrochloric acid, commercial raw hydrochloric acid?

Mr. Owen: May I call attention to this fact, Mr. Lyon, that this analysis is of the concentrated acid, not of the 15 per cent?

Mr. Lyon: That is right, the numbers should be divided in half. A. You should divide it half.

Q. I think you did. A. No, I didn't. The other is 15 per cent, so yours is different. The difference would not be as great. If your concentrated is .98 parts per million of copper, and if you dilute it it would come down half.

The Court: That is commercial? A. That is commercial.

Mr. Lyon: The commercial, the maximum is about 30 so it would reduce it to 15 per cent, to put in equal parts of water.

The Court: The commercial is about 70 per cent water and 30 per cent acid?

Mr. Lyon: That is right.

The Court: And when you talk about 15 per cent you just put half water to this commercial?

Mr. Lyon: That is right.

Mr. Lyon: Now, I started to ask you, have you any knowledge as to how much lead, copper and iron is usually

Dr. Carl F. Prutton

found in different raw commercial hydrochloric acids? A. No, I do not have such knowledge, but from the figures that I have seen from time to time on inhibition value of various commercial acids why I would say that the copper and lead content must be very low. I have seen many figures on inhibition of commercial acid.

Q. Are you familiar with the standards of the American Society for Testing Materials? A. Oh, I am not familiar on that particular subject. I know in general about them.

Q. Have you ever looked at them to see what tolerances on copper, lead and iron there are in commercial hydrochloric acid? A. I have not.

Q. Do you know whether the amount reported in PX-161 is an unusually high, unusually low or an average amount? A. I don't know.

Q. How did you come to get an acid with only a fraction of the amounts that are found in the defendant's storage samples, as reported in PX— A. (Interrupting): I can't answer that question at all.

Q. Who ordered the acid for you? A. I ordered the acid through our regular purchasing agent, I told him that I wanted regular commercial acid. The only thing that happened, we must have purchased 100 or 150 carboys—one batch of acid when we mixed it up and measured its inhibition, it was 30 per cent. That was just the commercial diluted, and we found that they had slipped in—during this last year the Grasselli Company is starting to make a special inhibited hydrochloric acid for some government work, and by mistake they had slipped in one of those carboys, and we dumped it into the tank, and noticing that the color of the tank was darker than usual, we ran the inhibition immediately before running the test, and found that it was 30 per cent. But every other carboy we bought, we put through this test, we did not throw out any of them.

Q. Well, now, do you have this handbook with you, of the testing society? A. I do not. The A. S. T. M. publishes—well, I have got a whole side of my library covered

Dr. Carl F. Prutton

with their publications. I do not know which one you are referring to.

Q. I want to ask you now a few questions about these tests that you made on oil? A. All right.

Q. Your tests show that the rate of corrosion of any of these acids will be reduced if the surface is oily, or has been oiled, covered with oil, isn't that correct? A. That is correct.

Q. Can you give us any idea as to the order of magnitude there of reduction in corrosiveness? A. The figures that I gave you were, when we immersed the same article, put it over again into our acid, it was 12.1 per cent, in straight acids, 15 per cent commercial acid. When we put 2 per cent of oil in with the acid, and shook it up, and then put our specimen in, the inhibition was 20.4 per cent. Can you interpret those results as to what will be the effect in the acidizing of a well, or running or pumping oil down a well ahead of the acid? A. Well, it would be indicative that you would get some inhibition due to the oil.

Q. You could not say from your tests how much that would be? A. I think in this particular case, in this oil from the Zahn well, which seemed to be very high in sulphur, according to the odor of it, at least, it had a much stronger odor than any of the Michigan crudes that I have ever smelled—with that you would get something like 10 to 20 per cent inhibition, and you would get that on top of the inhibition due to the metals.

Q. Now, of course, that effect of—that measurement that you got there is based on this burnished tubing of yours, that had been especially prepared and cleaned for the test: that is true, isn't it? A. Well, the metal was bright. I wouldn't say it was burnished.

Q. You run this wire on a machine, didn't you? A. It was not a real smooth surface finish. It was fairly smooth. I mean, you wouldn't tear your hand or anything. But there were plenty of points of contact on that surface that you might say could have held oil onto it.

Q. Do you think that you would fairly say that that

Dr. Carl F. Prutton

was true in a comparable sense to the inside of a piece of tubing that is ordinarily found in an oil well? A. Well, many oils show no inhibition, and this particular one—

Q. I was asking about the tubing. Do you think your cleaning up that tubing and scouring the tubing and treating it with the acid might have some little effect? A. It might have some little effect, but I don't think it would be appreciable.

Q. What is the condition of ordinary tubing as you find it out in an oil well, or at an oil well? A. Well, the stations I have seen, as I say, had a little rust and a little dark colored rust, and usually some oily film possibly on it.

Q. We are talking about the inside. A. Yes. I think that is the usual condition of it. Dark colored. In some cases it is fairly clean and in other cases it isn't so clean.

Q. As I understand, you don't have the weight of that tubing that you employed, per foot, in your tests? A. Yes; I gave you the figure, 2.4 pounds per foot.

Q. Is that the weight? A. Yes. I gave you that.

Q. Well, have you given me the percentage loss in weight that is represented by the figures that you have expressed in grams per hundred feet of tubing? A. Well, if it is 2.4 pounds per foot of tubing, and the tubing is 100 feet long, it is about 240 or 250 pounds. And dissolving two pounds or a little more off it, that is two pounds out of 240 or 250, that is a little less than one per cent.

Q. Well, as a matter of fact no experiment of yours consumed as much as one per cent of the tubing, did it? A. Well, let's see. We came awfully close on one of the tests, to one per cent. Very close. I think it was 1043 grams or 1050, something like that. And that is practically one per cent.

Q. That is the highest? A. That was the highest. And the lowest was down about eight or nine tenths of a per cent.

Q. Have you given us the average rate of penetration

Dr. Carl F. Prutton

of the tubing by the commercial acid, the raw commercial acid? A. You mean how many inches it ate back into the—

Q. (Interposing): Well, how much of a fraction of an inch it ate back. I figured it out here as .00039 inches per hour. You think that is right? A. If you figure down to an hour, you might get a low number like that.

Mr. Owen: Better figure it, Doctor. A. Well, I will.

Mr. Lyon: .00039 is what we figured from your data.

A. Well, I have to get the inside diameter of this tubing. I don't recall it offhand. And the specific gravity of steel, and so forth. I don't have those figures here.

Mr. Owen: Perhaps Mr. Lyon can give them to you.

A. The inside diameter of inch and a quarter tubing. Have you got it?

Q. (By Mr. Lyon): The outside diameter is 1.66 and the inside is 1.38. A. And the specific gravity of steel?

Mr. Lyon: 7.8. A. The figure I get for the thickness of iron dissolved is about .00044.

Q. My associates here seem to take considerable exception to your statement that an ordinary chemist could have calculated the effect of this lead in the tank and they want me to ask you some more about that. A. I have indicated, in discussing Menaul—you asked me if there was any merit of invention in the thing, and I said that there was some possibly.

Mr. Lyon: My associates are pacified by the witness's last statement that he acknowledges that Mr. Menaul made something of a discovery. A. I think there was some element in there. I wouldn't say that it was real obvious. I think that there was some little element to protect the storage tank there.

Q. Now, coming back to the tank and the source of this copper, do you think any of the copper comes from the walls of the tank? A. I believe so.

Q. Ordinary steel would have copper in it? A. Some little copper in it.

Q. When you get down to talking about one or two parts per million, it has got to be pretty pure not to have

Dr. Carl F. Prutton

it? A. These ordinary steel tanks are not usually used to carry hydrochloric acid in.

Q. Don't you believe if anyone attempted to transport commercial hydrochloric acid out to a well in a steel tank, by the time they got there in an ordinary case they would have as many as two parts of copper per million in the acid? A. I don't know. They might have. It would depend on what kind of steel they use, and the rate of attack, which I can't tell you.

Q. How much copper does ordinary steel have, the kind of steel you make an oil tank out of? A. As I recall, that is quite variable. It may run a couple hundredths of a per cent or maybe run higher.

Q. Now, I think you said there was how much copper in the lead of this lead plate that you bought or used? A. I have an analysis of that lead, if you want the exact percentage of copper?

Q. Yes, I do. A. Around five hundredths or six hundredths.

Q. You better look at it and be sure of that? A. Mr. Lightfoot, do I have that sheet up here? I don't know that I have. It met the specifications of chemical sheet lead, I know that. This analysis shows .063 per cent copper.

Q. What do you mean, it met the specifications? A. From the A. S. T. M. We received a letter from Mr. Rebbeck or someone, the information that this was chemical lead, and he gave us the specifications, and we looked it up in this A. S. T. M. book of specifications for lead and for chemical lead the copper maximum is .08 and the minimum is .04, and this sample was .063, so it came in about the middle. The rest of the elements are listed here.

Q. Iron and lead and copper? A. Iron, lead, copper; they are not listed, no. The metals listed here are bismuth, maximum of .005 per cent. Iron, a maximum of .002 per cent. Zinc, a maximum of .001 per cent. Arsenic, antimony and tin together, a maximum of .002 per cent. Copper, I gave you the upper and lower limit. Silver—

Q. That copper is .08 per cent? A. Yes. And silver,

Dr. Carl F. Prutton

a minimum of .002 per cent, and a maximum of .020 per cent. Now, you asked me a question as to whether there were any specifications on leads that were commercially available that had no copper in them, and here is one that is called corroding lead, and I am quite sure that is very low cost. I am sure that is used to make white lead, and that white lead sells at a very low price.

Q. Is that the kind of lead you would have in this sheet that you put in the tank, or is that a powder? A. I think you can get lead in any form you want. The copper maximum is .0015 per cent, for this corroding lead. That is where I got the idea it was a commercial lead that was very low in copper.

Q. What is meant by chemical lead? Does that mean the kind of lead where you use it for chemical operations, where they want a relatively pure lead? A. I don't know exactly. I think probably it is but I am not sure.

Mr. Allen Owen: May I call the witness' attention to the fact that there is a note at the bottom of the page describing those leads. A. Oh, yes. Corroding lead is a designation that has been used for many years in the trade to describe lead which has been refined to a high degree of purity. Chemical lead has been used for many years and it is a de-silverized lead. Acid lead is made by adding copper to fully refined lead.

Q. And you are willing to accept the view that the kind of lead plate that you employed in your operation did not constitute a deliberate attempt to add copper to the acid? A. I don't want to go into motives. I couldn't tell you motives. I don't know. The fellows looked pretty honest to me.

Q. If you had been interested in this system five or six years ago and hadn't known that this copper had any effect at all, you would have purchased this same kind of lead, would you not? A. I don't know. I don't know.

Q. Were you the one that discovered that this lead—this copper in the lead was the bad actor, or the infringer in this operation, or did somebody tell you about it before

Dr. Carl F. Prutton

you went to work on it? A. I had heard it, as I said before, I had heard almost from the time of the Grebe-Sanford invention that copper was an inhibitor for hydrochloric acid, and when I saw these analyses that Dr. Bartell made, that was the one possibility.

Q. You recognized it as a possibility then. You had to go to work on it to check it and see? A. Well, if I knew copper was an inhibitor and it was present in this acid, why the logical thing was that it was an inhibitor in the acid.

Q. In what form was copper used there by Grebe and Sanford as an inhibitor? A. I couldn't tell you that. I said my recollection was very vague; that I knew copper was an inhibitor and knew that general statement, but I couldn't tell you the amounts or form or anything else. I knew copper was an inhibitor and I can produce documents to show that.

Q. Let us have them. A. I am going to do that. I can't do it right now, sir.

The Court: Does it show what copper does? A. It plates out and the hydrogen that is plated out with the copper is held on tight by the few molecules of copper that are plated out.

The Court: Is there any kind of inhibition, except that kind that puts something on the iron to prevent the hydrochloric acid from eating it? Is there any other kind of inhibition? A. I think when you get down to the fundamentals there is no other kind.

The Court: We had some talk earlier here about two kinds of inhibition, one of the kind I have described, and the other one which in some way pulled the teeth out of the acid, so that it could not bite, but I have not heard in all of the testimony any description of that, or any formula for it.

Mr. Lyon: I tried to get into that a little while ago, but I did not get very far. A. It is my belief that all of them act by forming some film. I believe that the thing that stops corrosion is the film, a film of some kind. It may

Dr. Carl F. Prutton

be started by some electrical action, as they claim practically happens in their truck tank, but—

The Court: Well, I will take that until somebody else claims to the contrary to know about it. Let it go at that.

Mr. Lyon: Well, now, it looks from your figures as if the copper was accumulating in the acid in the tank, in the Menaul operation, faster than the lead was, in the proportion that you have found the copper and lead. Did you notice that? A. That is correct.

Q. Can you explain that? A. Yes, because the lead in corroding forms lead chloride, which is relatively slightly soluble, some of that dissolves in the acid; but the copper when it dissolves, it forms a very soluble compound, and it goes into solution; but to get the lead which has corroded from the sheet of lead into the solution, you have to use a tremendous amount of agitation, and that is a film of lead chloride over the surface, and that is why the copper is in greater proportion than the lead.

Q. Is your statement that the copper plates out based on an actual proven experiment, or is that your opinion of it? A. That is my opinion, and the opinion is based upon the fact that if you put this copper in—without copper in solution, you have your hydrogen plating out on the cathodic parts—when you put your copper in your hydrogen goes out and forms this film, and the only way that you can get that polarized film of hydrogen is to have your surface altered, and the only way it can be altered is by plating out the metal in solution.

Q. It can't both be plated out and stay in this solution in the soluble form that you have described here. Which does it tend to do? A. It dissolves from the lead and plates out on the iron, a small amount of the copper plates out on the iron.

Q. Have you ever actually found that on iron? A. No. I say, there is just a molecule here, and a molecule there, but if you have got to explain the altering of that surface, the formation of a polarized film on there, the only way that you can explain it is by having a minute

Dr. Carl F. Prutton

amount of copper plating out of the solution on to those parts.

Q. Doesn't the lead tend to affect the surface as described in the Menaul patent? A. Yes, with the lead plating out, you get that lower voltage helping to plate out the copper on to the iron, but it is not very great.

Q. Is that tending to plate out the copper—is the lead helping to plate out the copper, or the copper helping to plate out the lead? A. Oh, no. I would say the lead has some very slight effect in helping to plate out both copper and lead, but it isn't very much, it hasn't enough voltage. There isn't enough voltage to plate a continuous film of either one of them.

Q. Well, isn't it true that according to your figures there is 16 times as much copper accumulated in the acid as there is lead on the basis of the portion of copper that you say existed in the lead? A. I would have to do a lot of calculating to answer that question. I will state right here the amount of copper increase in the solution is considerably greater than the lead that goes into solution, several times, probably. I have stated some of that copper undoubtedly comes from the tank. Just how much, I don't know.

Q. As I understand your statement, you were the one that first suggested to the Dow Company that the thing to emphasize in this case was this presence and action of 3 parts per million of copper, is that correct? A. No, that isn't right.

Q. I said "I understood." I ask you for the fact. Were you the first one to develop this theory? A. No, I don't believe so.

Q. Who told it to you first? A. I don't recall. I have had many talks with Mr. Chamberlain and Mr. Rebeck and the thing evolved.

Q. Did you have this theory when you started to work on the case? A. I had talked to these men even before we started to work. It wasn't a gradual thing that they came up to me one day and said: "Here is a bill of goods. You

Dr. Carl F. Prutton

do that." You talked generally about the thing, and when we got to a certain point we began to do the work.

Q. You say "gradually evolved." What evolved? A. Discussion. When we saw Dr. Bartell's figures, they came up in the discussion. I don't know who had the idea. I had heard discussed this copper is an inhibitor.

Q. This theory copper is an inhibitor is an evolution of discussion and development of a proposition as you went along in these experiments, is that right? A. The first time I ever heard of the Menaul process was in a discussion I had—I don't recall with whom but someone in Dowell, and it was the same conclusion we have now reached, that the Menaul patent was a front, a method of getting inhibitor into the acid, in order to practice the Grebe-Sanford patent, and I have never changed that idea since then while we have gone along.

The Court: Did the lead do it? A. I don't think we had analyses to prove it. Possibly the lead did, or something in the lead sheet. We couldn't tell but we felt they were dumping in inhibitor to help the thing out. That is the thought that came out in everyone's mind. I never have heard that thought resulting in proof; it was a developed process.

The Witness: Did you want this publication on copper inhibitors? You asked me for that.

Mr. Lyon: Yes. Whatever you have got. A. Here is one reference that they dug up for me here some place. Should I read it?

Q. If you can. What is the reference? A. It is from the Automotive Industries, December 5, 1918. And reading the quotation—"Tin and copper salts are representative of the inorganic type of semi-collodial inhibitors." And the article is on the chemistry of pickling baths, which is a—in which inhibitors or the development of inhibitors was quite an important thing.

Q. Would you say that that article represented the regular view prior to Menaul's invention? Wasn't there a great deal of literature in connection with electro-chemistry

Dr. Carl F. Prutton

to the effect that copper increased corrosion? A. I wouldn't admit that. I don't think that is the case. I can't give you any definite proof as to what the general knowledge was or anything else, but when people publish material like that, why, it indicates that somebody found that copper was a pretty good inhibitor.

Q. Does that say for hydrochloric acid? A. I think it said pickling solutions, and I don't know what acid—usually sulphuric acid, but usually in the inhibitor art if they are fairly good for sulphuric they are pretty good for hydrochloric, as a rule. There is no exact correlation. I think I have lost my place.

Q. Is that the best article that these folks can— A. (Interposing): I asked Mr. Rebbeck here a minute ago, and he just gave me the one. In my general reading on the subject of electro-chemistry and inhibition, why, I am quite sure I ran across the mention, and I can't say how many times, but it is a typical illustration of what is in the literature.

Q. Now, you tell me what just adding copper indiscriminately as copper to one of these baths would do to a steel tank, or steel car? A. Well, I would say that there undoubtedly is some optimum composition or concentration of copper for each different acid solution and so forth that gives you the best results, and if you exceed that you might get a continuous, complete coating of copper deposit, or it might be loose, and it might cause detrimental effects. I will grant to you that if you exceed a certain concentration of copper in solution that you probably would get some detrimental effects and it would not be an inhibitor.

Q. Well, that is the point. And do you know of anything in the art that taught, prior to your work on this case, that these minute amounts of copper which you are now talking about down to not more than five parts per million had this effect that you have shown here? A. Well, it is true for every inhibitor, that if you add an increasing amount of inhibitor you get generally increasing inhibition, and there are some of them you go up over a

Dr. Carl F. Prutton

hump, and then down. But to try to find that hump is hardly an invention.

Q. Well, I am not asking you that. I am asking you if there is any public disclosures of the fact that we have here in this case? A. Of adding it to hydrochloric acid?

Q. Yes, prior to your work on this case? A. I don't think so. But the fact that copper was used to inhibit acids, it is just like telling somebody to put some salt in some food. Well, you put different amounts of salt in different kinds of food for different people. You put the right amount in to make it taste right. So you put the right amount of inhibitor in your hydrochloric acid to make it do the job.

Q. Would you have known from this manual that you have just had read here how much copper to put in to do the job? A. No, but I would have turned it over to a very inexperienced individual that would have tried it, knowing that it was an inhibitor, having been told that it was an inhibitor, he would try the different concentrations and find the correct concentration.

Q. Did you every talk with Mr. Rebbeck or Dr. Grebe, or anyone in the Dow organization, as to what he had in mind in the statement in the patent in suit, No. 1,877,504, commencing at line 75, on page 1, where he calls for adding a small amount of a substance capable of inhibiting attack of the acid upon metal surfaces, e. g. of iron or steel, copper, etc.? A. I would like to read the language of the patent. The statement is, (reading): "To the acid we add a small amount of a substance capable of inhibiting attack of the acid upon metal surfaces, e. g. of iron or steel, copper, etc., with which it comes in contact."

In other words, you put some material, a small—a relatively small amount into an acid, that will slow up the rate of attack of that acid upon the metal surfaces that it comes in contact with. Now, in an oil well, that is usually steel.

Q. Well, now, in the Menaul system, is there anything added to the acid that inhibits its attack upon a metal surface, if that metal surface is copper? A. I don't know. I haven't made any tests.

Dr. Carl F. Prutton

Q. You know, don't you, that the presence of this copper is due to some action of the acid, in the Menaul process? Didn't you tell us that some of this copper could have come from bronze or a copper pump or fitting in the system? A. Yes.

Q. That would be because the acid would attack the copper, isn't that true? A. It would attack copper alloys. It might not necessarily mean that it would attack copper. I don't think the patent implied that it would inhibit the attack on all metals, just the metals that it encountered in the well. For example, if the well was iron or steel, it inhibited iron or steel.

The Court: And if it was copper, it would too. A. Well, if there was copper in the well, it would, if you had an inhibitor that would inhibit it if it was attacking copper, yes.

Q. The claims in this patent are not limited to steel or iron but to include acid upon metals, you have noticed that, haven't you? A. But if you have a well with all steel equipment, then the patent teaches, in my opinion, that you add an inhibitor that inhibits the action of acid on the steel. If you have a well that has a different metal in it to contact the acid, then you add an inhibitor to inhibit the action on the other metal, copper, for instance. If you have a mixture you try to get an inhibitor that will do a good job on either one of them.

Q. The point is nothing in the Menaul system includes any adding to the acid of a substance capable of inhibiting the attack of acid upon copper. You agree to that, do you? A. I do not agree to that, because I cannot answer the question. I cannot tell you whether the lead and copper in solution in the Menaul acid will inhibit the attack on pure copper. If you take raw acid and you take a brass valve or some alloy like that, I believe you would get some copper going into solution. I don't know what would happen after that. I do not know whether it would attack the brass or the bronze or pure copper.

The Court: I am wondering if I get into this dilemma,

Dr. Carl F. Prutton

that if I did not put in anything—if they would both be there, copper and iron, and I didn't put anything in, to inhibit its attacking the copper, then it would attack the copper and make an inhibitor for the iron, and I would be in a mess. Supposing it has got copper and iron and I use pure acid, am I liable, is it chemically possible here that that acid would get busy in the copper and get enough of that little bit of copper out so that it will make an inhibitor down in there against the iron? A. I would say that if the acid contained sufficient copper, no matter where it came from, sufficient lead no matter where it came from, sufficient inhibitor of any kind no matter where it came from, except from the Menaul practice of commercial acid, in other words, if those things were added extraneous, I mean it went into the well, the top of the well, if you took and pumped that acid through a two inch copper pipe one hundred feet long, in order to get copper into it before it goes into the well, I would say that would inhibit the inhibiting acid going into the well.

The Court: It goes right down. A. Supposing down at the bottom, if that is normal construction in an oil well, which I doubt very much—I am not enough of an oil well man to tell you—if it is normal construction to use brass parts at the bottom of the well—I know it is not all the way up between the top and the bottom—if that is normal construction, you get some inhibition and I would say that probably is perfectly all right, because your acid has gone into the well uninhibited.

The Court: Now, you are answering a legal question. What I was really starting to ask you was the chemical question as to whether or not if there was copper down at the bottom of that well whether you wouldn't make the acid—whether you wouldn't get enough of that copper off so that it would make a practical inhibitor? A. It would depend on how much contact it got with that metal, but the acid in going by that would be leaving the metal system of the well and going out into the formation so you would have no effect.

Dr. Carl F. Prutton

The Court: Can you tell me how much the surface of the copper would bear to the amount of the surface of the iron to do the trick? A. I can't tell you that. I think it would have to be a fairly appreciable surface.

Mr. Lyon: Will you tell us what happened in the Frasch patent? A. I have not looked at it recently.

Q. He says there he can use a lead-lined tube in his well to put his acid in. If he used a lead-lined tube, what would happen? A. The acid would start into the well uninhibited. By the time it got to the bottom it would probably be somewhat inhibited, but again the inhibition would be completed when it got to the bottom of the well.

Q. Well, now, you have described the fact that this copper is in the lead. It is there as the metal copper in the lead, isn't it? A. That is right.

Q. When this plate is put into the tank. Now, it gets into the acid by being dissolved and forming copper chloride, doesn't it? A. Yes.

Q. Isn't that the way acid corrodes a metal surface, by dissolving material off of the metal surface to form a chloride? A. Oh, yes; that is the usual way.

Q. Then, as a matter of fact, all the copper that you found in this acid got there because of the process corresponding to corrosion, that is, dissolving the metal off of a surface? A. Off the lead or out of the steel tank, or in some way it got in there, and in a truck tank there are usually brass valves or some bronze equipment.

Q. Now, you said a while ago that copper is an inhibitor for sulphuric acid. Did you mean to say that? A. I say that it is apparently an inhibitor for solutions as reported in this article. I said in general inhibitors that work in one acid—that is, sulphuric acid, are usually fairly good in sulphuric and hydrochloric. They don't necessarily have to be good in both.

Q. What about copper? A. I don't know in sulphuric acid.

Q. You don't know whether copper is an inhibitor for sulphuric acid? A. I don't know.

Dr. Carl F. Prutton

Q. You read this article and it doesn't tell you what acid the copper is an inhibitor for, and you don't know whether it is an inhibitor for sulphuric. Now, did you know anything about whether copper was an inhibitor for hydrochloric acid before you started on this case? A. I very definitely did. That article talks about pickling. Pickling itself, done with several kinds of acid, usually sulphuric or hydrochloric. When they say it is an inhibitor I take their word it is an inhibitor. If I read that article in 1918 (I may have seen it—I don't believe I did) it made a mental impression on my mind copper was an inhibitor for non-oxidizing acids.

Q. You made a mental note of this article this afternoon but you don't know now whether it is an inhibitor for sulphuric acid or not. A. I will say from what I read (I can't say from my own experience—I haven't made any tests) but from my reading and understanding it was an inhibitor for the acids, hydrochloric and sulphuric acid used in the pickling art.

The Court: From reading that article, so far as your getting any information, copper would be an inhibitor for hydrochloric, it would be the same for copper as it would be an inhibitor for sulphuric. A. Yes, from the article. But by my own experience I have not run any tests nor could I possibly tell from my readings, and so forth. I would come to the conclusion not from any tests I have made. I have not made any tests for sulphuric acid.

Q. You said copper was an inhibitor because you read one article. Now, you have read this article this afternoon. Do you know whether copper is an inhibitor for hydrochloric—for sulphuric acid? A. There are different ways of reading things. You read it, get a picture, draw a conclusion that is a correct statement. Sometimes you don't perform the work yourself to verify it. You couldn't. So, part of my experience is based upon what I have read, picking up on reading of other people's work.

The Court: What I understand from your remarks is if teaching prior to your experiments that copper was an

Dr. Carl F. Prutton

inhibitant for hydrochloric acid, why doesn't it teach today that copper is an inhibitant for hydrochloric acid and for sulphuric acid? A. Well, I think it does.

Mr. Lyon: And you think you know copper is an inhibitant for sulphuric acid? A. I will say that there is probably some concentration, sulphur salt, salt compounds, that will inhibit sulphuric acid to some degree.

Q. According to your statement there was one part of copper to 1600 parts of lead, as I understood one of your previous statements, that is correct isn't it? A. One part of copper to 1600 of lead is correct.

Q. And in these samples of the acid that you analyzed from the Menaul tank after the acid had been in there for six or seven hours, you found one part of copper for 100 parts of lead, didn't you? A. I think something like that.

Q. Now, you have suggested that the reason for that copper increasing 16 fold is that lead chloride wasn't as soluble as the copper chloride, is that correct? A. I assume that we would be correct that the ratio that you get of copper to lead in the solution cannot be figured from the analysis of a sheet of lead; that you get a higher proportion of copper going into solution. I did not say all the copper came from the lead sheet, but if you would take a piece of this lead sheet and dissolve it, convert copper to copper chloride, lead to lead chloride, and then dissolve that thoroughly in the acid solution, you would have a ratio of 1 part of copper to 1600 of lead. That is correct. Now, if you take four times as much of that sheet of lead, or three times as much, or in some number like that, and convert that by reaction with hydrochloric acid into lead chloride and copper chloride and then contact that with solution, the copper will go into solution and in my opinion the lead chloride is much more difficultly soluble, and you will have samples of lead chloride floating around which we observed. Now, that would produce a ratio of copper in solution instead of 1 to 1600 about 1 to 400. I don't know what that number is. It might be 1 to 200. Then there is some copper that comes from the steel tank, and that I don't know how much it is either.

Dr. Carl F. Prutton

Q. Well, now, how many parts per million of lead chloride did you find in solution in the analysis of the acids from the Menaul tank, after the six or seven— A. (Interrupting): You mean Dr. Bartell's figures, or of the figures that I made in this laboratory test?

Q. In your test you found one part of copper to one hundred parts of lead, did you not? A. We got about three or four parts per million of copper to 250 to 400 parts per million of lead chloride in solution.

Q. What is the solubility of lead chloride in hydrochloric acid 15 per cent? A. I don't know.

Q. Don't you know that it was only a small part of the lead chloride that would dissolve in the acid? A. I assume so, yes. I did not say it was saturated.

Q. Then there is plenty of room in that solution, as far as you know, for more lead chloride? A. Yes, but if you take lead chloride and you try to dissolve lead chloride in hydrochloric acid,—we have made many of these synthetic runs—in making the synthetic mixture for the running of laboratory tests, we have had to shake them for a considerable length of time, and use special pulverizing methods to bring in the crystals. The rate of solution of lead chloride is very low. I didn't say that the solution was ever saturated in those tests, but the lead crystals form on the surface of the lead sheet and then break off and float in the solution towards the bottom, some sticking on the lead sheet.

Q. Can you tell us how much of the copper that you found in your analysis of the acid from the Menaul tank, was introduced into that acid, or got into that acid from the lead plate? A. I cannot tell. I would assume that it is between one and two parts per million, maybe two.

Q. Well, can you tell? A. I cannot tell, no, because it is impossible to separate it.

Q. Did you analyze the walls of the tank? A. We analyzed the steel walls.

Q. Do you know whether it had any copper in it? A. It had copper in it, yes.

Dr. Carl F. Prutton

Q. Do you know in what order? A. I don't know. I think it was around two-tenths of one per cent or so.

Q. Did you analyze the oil well tubing? A. We analyzed that.

Q. Did you find any copper in that? A. As I recall, we found about three hundredths of a per cent copper in it.

Q. But you don't believe you analyzed the tank? A. I don't recall that we analyzed the tank. I think we got some general figure from the man that sold the tank. We did analyze the steel that was submitted from your headquarters as steel that went into the Halliburton tanks.

Q. Did you find any copper? A. Fourteen hundredths of one per cent.

Q. Now, did you analyze the samples that you took at the bottom of the tubing for their copper or lead content? A. I analyzed those.

Q. Where is the report on that? A. We haven't got that in the report.

Q. What did they show? A. They didn't show much of anything. They showed that the copper going in and out was substantially the same.

Q. Same amount of copper? A. There was some change in some cases, but very little.

Q. Well, enough so you consider there was any change? Would the figures be enough different so that they showed a change beyond experimental error? A. Well, some of the figures in the effluent acid that were obtained when we ran the—as I recall the blank acid tests, the copper was analyzed on small samples, and we did not feel that the accuracy was any too good. I don't recall the figures. We got about one part per million in that effluent acid, and we actually took those samples and ran inhibitions to see if we could check back and see if they were inhibited due to the copper picked up from the pipe, and as I recall it the inhibitions were very low.

Q. Now, wait a minute. Let's take the commercial acid when it was run down the pipe and you analyzed the acid samples for copper? A. When the commercial acid was run down the pipe, we ran the exit samples for copper.

Dr. Carl F. Prutton

Q. Did you? A. In some of the tests, I don't know.

Q. And have you got the results there? A. I don't think I have them in any report here. I think they are in those notebooks some place, that I could dig out.

Q. Well, you remember what you found? A. I don't remember.

The Court: What would you expect to find? A. We expected to find that when the acid ran through the iron tubing, which contained a trace of copper, that the effluent acid would contain some small amount of copper over what the commercial acid did.

The Court: More? It would pick up? A. Surely. Because when the steel tubing is dissolved part of the copper is dissolved.

Mr. Lyon: Did you find that? A. We found that, as I recall, that some of it did dissolve.

Q. But you don't remember how much? A. I don't remember exactly.

Q. Well, now, what did you find in the case of the acid that had been in the Menaul tank for six or seven hours? What did you find out from the exit samples of that acid as to its copper content? A. I don't recall the exact figures on that. I don't think there was much of it at all.

Q. You mean the acid coming out, the exit acid, had just about as much copper in it as when it went in? A. That is my recollection.

The Court: What would you expect on that? A. That is about what I expected. There isn't much metal dissolved in the—

Q. (By Mr. Lyon interposing): Where has all this copper gone that is going to plate and protect the tubing? A. I told you it was only an atom here and an atom there. I wouldn't expect there would be much copper used up. Just a minute amount that is going to plate.

The Court: But that is the thing that is going to stop the corroding by the acid, is the coating that goes on, as I understand. A. That is true. But you take acid with a certain copper content and run it through a pipe and it

Dr. Carl F. Prutton

dissolves from the surface of the pipe iron, and some small amount of copper, and you have or may have that plate on certain areas of the pipe and the copper go in solution from the pipe. I just don't know how, but the effluent may not be greatly different. It may be a minute amount different.

The Court: Why don't the—if that is all this inhibitor does, is to do that spotty job of plating, why don't the acid eat the places that are not plated and make pits? A. Well, that is the part, where it is not coated with the copper, is the part that is the pure iron, and the cell—the copper over in these other parts is putting this hydrogen layer on that and prohibits that cell from acting, the iron dissolving, and the hydrogen plating.

The Court: I am talking about the spots that are not coated. A. That is what I am saying, that in order for the iron to dissolve you have to have this electro-chemical cell to function, and some of the parts of the steel that are pure iron, that are not coated with copper, the copper coats over on the impurities and builds up this hydrogen field which prohibits that little corrosion cell from functioning, and before the iron can dissolve, although it is bare, it has to be connected in a complete electrical circuit.

The Court: Well, then, over in this pure iron place you show there is where the hydrogen is? A. Over the impurities is the hydrogen layer; the pure iron is just uncovered.

The Court: Well, why doesn't the acid bite it? A. Well, the belief is that it requires this electrochemical action for the solution to occur. You have got to have a complete electrical circuit and the motion of the ions.

The Court: In order to have the iron— A. (Interposing): Dissolve.

The Court: In order to have the acid act on the iron? A. On the iron. But the quantity of copper is very little.

The Court: You just spoil that part of the battery that you start the thing going with, the impurities. A. Yes.

Dr. Carl F. Prutton

CROSS EXAMINATION (Continued)

Mr. Lyon: First, Your Honor, I might state that the plaintiff delivered to us two bound books, they seem to be ledger books, which I am going to ask the witness to identify for the purpose of the record; and, in addition, they delivered to us five holders of what appear to be preliminary reports, which I am also going to have him identify, so the record will be clear. The first of these books has written on the inside front cover the following:

(Reading): "Data book Menaul test, Dow vs. Halliburton, September 1, 1939, C. F. Prutton."

Mr. Lyon: Dr. Prutton, can you tell us what this book is? **A.** That book contains the data that were taken during the work on these tests that have been reported.

The book was marked for identification DX-190.

Mr. Lyon: Is this book in your handwriting, or are the entries in this book in your handwriting, Dr. Prutton?

A. Very few of them are. Various writings in this book are signed by different individuals. For instance, the first subject, commencing on page 5, and ending on page 19, is signed "William J. Lightfoot," who was one of my assistants.

Q. I notice beginning on the first page of this book, DX-190, is an index and that this index, under the description or title "Description of Run" commences with a series listed A, B, C, D and so forth, and then in the next column is what appears to be a modified or revised listing changing the numerals of the run, and then there is a third column in which there is a second revision. Can you explain that? **A.** No, I can't explain that. We simply ran these runs at random and they were all mixed up. The Menaul tests, and so forth. And when we came to write, to split them up and write a report on the Menaul tests separate from the report of the crock tests, why, we changed the designations of those so that they would be more in order.

Q. Well, the reports which have been offered in evi-

Dr. Carl F. Prutton

dence here, Exhibits PX-184 and PX-185, present the data in somewhat different recalculated form than what appears in DX-190; that is correct, isn't it? A. Yes, I think there is a little difference.

I did not personally prepare the tables that are set forth in PX-184 and PX-185. My recollection of the way in which the written text of the reports and statements contained in PX-184 and PX-185 is that I wrote it up in long-hand and had Mr. Lightfoot go over it and edit it to see if it should be corrected somewhat, and then I worked over the final draft so I would say that I probably wrote it.

As to the order of the experiments recorded in DX-190 and which of those experiments or runs are reflected in PX-184 and PX-185, might I ask Mr. Lightfoot to help me with this? He kept most of the books here, and the data, and so forth.

The Court: Would you like to have him sworn? I don't care to, but they did that before. When Dr. Bartell was here, we had his associate, and as I remember they were both sworn as witnesses.

Mr. Lyon: Perfectly all right with me. I am not interested in this witness except to get the facts before Your Honor in the quickest way.

Mr. Lyon: Now, the first run recorded in DX-190 is written up commencing at page 26 of DX-190 and continuing through to page 35, and is signed by Merrill L. Reihl and is dated 11/24/39, entitled "Run No. A." Can you tell me whether or not the results of that run were reported in PX-184 or 185? A. I don't believe they appear in any of the reports. I am not sure. That was the original set of tubing that we did not use in any subsequent runs. We found out that different lengths of tubing gave different corrosion rates and therefore we picked out two subsequent sets to run the remaining tests on. That was my recollection. That was one of the first runs.

Q. Well, how do the results of that run compare with the figures that you arrived at in your conclusions in Exhibits 184 and 185? Can you state at this time? Were they higher or lower?

Dr. Carl F. Prutton

Mr. Lightfoot: I believe about the same.

A. I think they are the same order of magnitude. There was not a great deal of difference. As I recall, we used a 100 foot length of tubing in the run and we got a lower amount of iron dissolved.

Q. Run A commences on page 26, and after a description of the run a suitable length, it contains record of the exact determinations. It doesn't look to me as if that run is any different from others that you made. It seems to have entirely different results. A. Well, 200 gallons of acid, practically, so that it was similar to the other runs. Can you find the others for me?

Mr. Lightfoot: May I have the reports? This contains the calculations.

A. (Witness continuing): The numbers are here but you have to do a lot of calculating to get the results, make analyses, and so on.

Q. What I am trying to get at, compare these actual measurements with other measurements in DX-190 and tell me, if you can, why you discarded the work that is represented in this one run. A. I told you my general recollection was it was in the same order of magnitude and we had no similar runs to this particular tube.

Q. Let's be sure of that. I think the tubing is described on page 25 and under the title of "Equipment" item 2, "5 lengths of 1 $\frac{1}{4}$ C45 API external upset tube range 1000 AC 2.40 points obtained from Oil Well Supply Company. Tubes are new and have not been used." Now, aren't those the same tubes used in subsequent runs? A. According to my recollection they are not. We bought 22 tubes, as I recall, and we used each one of them. When I say we used Set No. 1 it means a certain number sequence number test. These tubes were not used, is that correct?

Mr. Lightfoot: That is correct.

(Witness continuing): In other words, we cut up tubes to make corrosion inhibition samples. The calculation on that run was 622.9 grams of iron dissolved. Now, we had other blank runs that ran 791 grams of iron dis-

Dr. Carl F. Prutton

solved. This was lower than the lowest of the blanks that were reported but we had no subsequent work on those tubes, that set of tubing; some of the tubes were sawed up to make fittings and to make samples, and it was on that run that we found out that different lengths of tubing would corrode at different rates, and that there was a difference between two different lengths of tubing and therefore either following that run or about the third one—I don't recall which—it is several years ago, we came to the conclusion that we had to take Tube 13, 14, 15, 16, put them all in a row in the same order and run the same tests through that tubing, give it a good cleaning after each run and then we could get comparative results.

Mr. Owen: Doctor, was this length of this tubing, this first set of tubing, the same as the later ones? A. It was somewhat shorter. I don't recall the exact length, do you?

Mr. Wiles: With different lengths of tubing you are using the 20-foot pieces? A. Yes, a 20-foot length of tubing when we ran acid through we might have 140 grams of iron dissolved from one length in the same run, and the next length might dissolve only 120 grams. There was a difference in the tubing and we determined after the first run or two that we were going to take a definite sequence of tubing and use it in a whole series of tests so that we could figure what the raw acid did on these sheet tubes, and on the same tubes after they were cleaned on the inside we would determine what the inhibited acid would do.

We would determine what it would do on the Menaul tests and without the wire, and the results we reported are the results of those tests run upon two completely separate series of tubings, and this result, if you take that even at its face value, and assume that it was cleaned out in exactly the same way, and that we ran it exactly the same as the rest, and this was the first run we made, and the men doing this cleaning operation probably had not standardized quite as well as they did on subsequent tests, and the first test that we ran, all the data is in the book there.

We did not run any preliminary tests and throw away

Dr. Carl F. Prutton

the data. That is the first run we tried and the results even if we take that as a blank, 622 grams dissolved. We can use that figure to compare the inhibited acid. The answer would be we get 50 per cent inhibition. In other words, the acid is still inhibited, even if you use that other low one as a blank. We have five blanks, as I figure. Four we reported and one we took as our first preliminary run. Even if we take this low one and use it as our standard reference figure for the uninhibited acid, still this acid with the lead and copper in is 50 per cent inhibited. In other words, that dissolved in the acid with lead and copper in, the amount of iron dissolved was from 160 to as much as 300 grams. It was down there less than a half as much as even this lowest blank and of course we did not incorporate it, or rather the reason we did not incorporate it was simply because we hadn't found out yet. We thought when we started out, we ordered from the Oil Well Supply Company this tubing, and we told them—I talked to whoever took the order, the sales department, and I told them I wanted to be sure I got this tubing from one mill run in order to get uniformity, and he said he couldn't guarantee that it would be from one mill run, but he was quite sure the tubes he would send us was from one run of the mill.

They buy a large amount of tubes and we thought if we got them the same we could more closely duplicate the tests we were making, and then this run, in this run we found that we got a difference between different lengths of tubing of about 20 per cent in the rate of attack of the acid, and for that reason we came back to the system figuring that we had to use the same tube and the same order and run the tests through that same tubing system.

Then to check on that we took an entirely different tubing system and run our tests. This first tubing system, in some of our preliminary work we cut some of those tubes to make elbows and to make small samples, and those tubes, I don't know whether they end, any of them ended up in the final lengths of tubing or not.

Mr. Lyon: Now, this run A commences at page 26 in

Dr. Carl F. Prutton

DX-190, and I would like to just have the court understand what is in DX-190 before the recording of that first run. I am correct, am I not, that following the index which covers pages 1 to 3, the next entry commences on page 5, and continues to page 19, and is signed on September 11, 1939, by William J. Lightfoot, and is entitled, "Copy of Dr. Bartell's report, dated January 20, 1939." A. That is correct.

Q. That report, before you undertook this work, you had Dr. Bartell's entire methods of analyses, the results of his analyses, in connection with iron, copper and lead, entered in your book to start with? A. I don't recall whether that was entered or not. I think there was just a copy of his report.

Q. Will you just take a look at it? (handing Exhibit DX-190 to the witness) A. As I recall, we obtained through Mr. Chamberlain one or two of Dr. Bartell's original reports, I mean, the preliminary work that he had done. In this material copied in here, it is mainly the methods for determining iron, copper and lead in minute amounts from acid solutions that I believe or understand that Dr. Bartell got through Dr. Willard, the analytical man at the University of Michigan, and which he had used, and we wanted to use the same methods. As I recall, and you might check me on this, Mr. Lightfoot, the figures that are reported here were some preliminary figures that were taken out of these very preliminary reports of Dr. Bartell, and the method for copper that is given here I think was replaced by another method that was more accurate.

Mr. Lightfoot: That is right.

A. We had trouble in getting very good checks, determinations, as I recall, using this particular method on our particular samples.

Our samples were different than Dr. Bartell's, in that there was a considerable amount of iron present, more so than in the defendant's truck samples. If you will remember the analysis, the average analysis reported by Dr. Bartell was some 400 parts per million of iron; and in the

Dr. Carl F. Prutton

samples we had, the iron was up around 1300, and even higher. In other words, the acid that we made in our Menaul tank had a considerably greater amount of iron, and, therefore, there was a possibility of the iron interfering to a greater degree in the analysis, and we found that we could not get extremely accurate checks with this method. That was subsequently replaced by another method of copper analysis which is shown in the report. The method of copper analysis that we used on all of the determinations is shown in our report, and I am not sure if it is in this book, or not.

Q. Well, does that first entry in DX-190, particularly insofar as it is directed to the determination of minute amounts of copper, refresh your recollection on the point which I asked about yesterday as to whether or not when this work was presented to you, or you were called upon to do this work, you received the suggestion from others that what they were interested in was establishing the effect of these minute amounts of copper? A. Well, I have told you that I had contact with this case and knew of this Halliburton procedure, and so forth, before Dr. Bartell was connected with this case, and, therefore, I am very sure that he did not tell me about the copper. I knew that copper was an inhibitor, had had general knowledge. I had seen—it is difficult for me to figure out just where I first got the information—as I recall some five or six years ago. I started to see analyses of the Halliburton acid that were run in the Dow plant, and the discussions that were had as to the validity of the method and as to how they obtained protection or inhibition, which these samples always showed. And I can't tell you exactly when I first found out that copper was present in the Menaul or the Halliburton acid samples. But I don't believe I obtained that first from Dr. Bartell. I am sure of that. But it is difficult for me to remember back.

Q. Well, you are quite sure, are you not, that before the samples were obtained from these four Michigan wells which have been reported in evidence here that the Dow

Dr. Carl F. Prutton

Company had obtained many samples of Halliburton acids and had analyzed the same and studied the same and you were in on some of those discussions? A. I had seen some of the tables of results of the analyses of some of the acids, and the inhibitions that had been run upon them, and I think it was probably from some of that work that I got definite information that copper was present. I think so.

Q. When was that? Have you any way of telling us when the idea first presented itself that there were minute amounts of copper in those test acids and that that should be studied to see if they were giving the inhibiting effect?

A. It really is—there are so many little discussions and little mentions made of the thing, and with so many different people, that I couldn't put my finger on it. It was at least five years ago, I believe, and Dr. Bartell, I think, has been associated with the work only about two.

Q. All right. Now, just to continue with the contents of Exhibit 190, following the entry of Dr. Bartell's report which concludes on page 19, then we have on pages 20 through 21 some analytical work for determining the carbon in steel samples. A. Well, I don't know. We received, through Mr. Conner, samples of the steel which was supposed to represent the type of steel used by Halliburton in making up their truck tanks, and I turned them over to Mr. Reihl to analyze and told him I particularly wanted copper determined in them, and he went through, as you do in steel analyses, and just ran everything. He ran carbon and I think silicon and some of the other elements.

Q. The entries of those analyses cover through to the end of page 23 of DX-190, that is correct? A. I believe so.

Q. Now, on pages 24 and 25, under date of October 30, 1939, you have an entry of comparative runs to determine the corrosiveness of commercial hydrochloric acid that you purchased from the Penn Salt Manufacturing Company and the Grasselli Chemical Company; is that correct? A. I don't even recall that we had any acid from Pennsylvania Salt.

Dr. Carl F. Prutton

Q. Just examine that entry. A. I don't remember that. Did we buy the acid?

Mr. Lightfoot: No.

A. Where did we get it?

Mr. Lightfoot: We asked for samples.

A. We got the sample from Pennsylvania Salt Company of the acid, and samples from Grasselli and ran comparative corrosion tests and recorded them.

As to why we selected the Grasselli acid instead of the Pennsylvania Salt Company acid, I recall they were about the same, and we just took the Grasselli because it was in Cleveland and we could get the acid delivered immediately and without any trouble and we could return the carboys, and there was a lot more convenience. I don't recall why we got the Pennsylvania Salt unless somebody suggested it to me. Somebody must have suggested it to me, because I didn't definitely recall that.

Q. The next entry in DX-190 commences on page 36, entitled "Run No. B" dated December 16, 1939, and after the description of Run B and the entry of the data there is a table on pages 42 and 43 of the results. Those results were not carried forward or used in Exhibits 184 or 185. Can you tell us why? A. I cannot tell you why. The comments I have here, there was not enough data taken in the tank samples to permit making calculations.

Mr. Lyon: Look at the data and see if you can confirm that statement. A. This test was a peculiar test that I described to the court in my direct testimony, in which we tried to run the acid through this Menaul tank so fast—

Mr. Lyon (interrupting): No.

(Witness continuing): I am telling what Mr. Lightfoot tells me. Ran it through so fast without this agitation.

Q. Before you go any further on that, I call your attention under the title "Conditions of Test under 41—The rate of flow through the pipe is to be 1 gallon per minute." That is the same rate you used in the other tests. A. We ran from the crock. Let me explain we ran from the crock to the steel tank and then we gave no six-hour agitation

Dr. Carl F. Prutton

but ran it immediately at 1 gallon per minute through the tubing in order that there would be no time to pick up the inhibiting metals in that tank, and we would have all the conditions of the Menaul process without any metallic inhibitors in there.

Q. That is your understanding?

Mr. Lightfoot: Yes.

(Witness continuing): But when we got through we found the iron picked up from the tank the acid got richer and richer in iron and lead, that the copper went along, and the acid was fairly well inhibited due to the metals by the time it got to the pipe. Therefore, we got a combination inhibition due to the metals picked up. It was sort of an odd test that we didn't include, therefore.

Q. Under Item 8, page 37, which bears the title "Condition of Equipment" is this entry—"To polarize the steel tank before the run it was filled with 200 gallons of 15% hydrochloric commercial grade and a lead electrode was placed in the acid and a storage battery fully charged was allowed to discharge through the solution. The battery was connected so that the lead plated out on the iron tank. The time of the discharge on the battery was 24 hours, i. e. the battery was allowed to remain connected for this period." A. That is about right. That is the polarization I described in the report.

Q. Then under page 40 is a diagram of the equipment and shows the same layout as was employed in the tests that you have reported here? A. That is correct.

Q. Under the title of "Conditions of Test" on page 41 the entry reads: "15% hydrochloric acid to be passed from the stoneware crock to the steel tank and directly through the piping system. The temperature of the acid to be 85° F., the hydrogen to be vented at the T, the rate of the flow through the pipe is to be one gallon per minute, the T in tank to be connected by electrical conductor copper wire. The tubing is not to touch the tank. Just before the run the steel tank was washed with 25 gallons of 15% hydrochloric. This was syphoned off and dis-

solved," does it not? A. That is correct. To make it more intelligible you want to put the emphasis on 15% hydrochloric acid to be passed from the stoneware crock to the steel tank and directly through the piping system. In other words, without the six-hour waiting period.

Q. Now, on the next page is a tabulation and the data of this run, and the run consumed from 1:52 P. M. to 5:06 P. M., as shown by the time-table in the first column. That is correct, is it not, Doctor? A. Yes, that is what it shows there.

Q. The data in this table shows much less corrosion than in the figures that you have presented in Exhibits 184 and 185, does it not? A. That is correct, and that is due to the picking up of the metals in going through the tank, which I explained to you—

Mr. Owen (interposing): What run does that data refer to that you have just mentioned? A. It is run B in that particular designation in the book. We have not reported that, because it was a combination of—well, we got partial inhibition, due to the metals in the solution.

Mr. Owen: That was one where you ran the acid direct from the steel tank, without letting it stand in there? A. Without letting it stand. Of course, the acid was in the steel tank for three hours, some of it. In other words, we put the acid in the tank and started to discharge it at the rate of a gallon a minute, but the test lasted for three hours, and, therefore, some of the acid was in there three hours, and the average was an hour and a half, I think, in there, and it is logical to think that that would—that you would get some inhibition there. We could not figure the iron because—and that is where we found out how we had to run these Menaul tests—the iron content in the Menaul tank would increase during a run, and we were innocent enough to believe that the tank would be inhibited by this lead sheet, and that the iron content would stay constant, and we took, as I recall, one sample—

Mr. Lightfoot: Two samples.

A. — two samples out of the tank, but in later work

Dr. Carl F. Prutton

we took a number of samples, every twenty minutes, so that we could have the iron concentration in the Menaul tank, and as it stood in the tank, the iron concentration went up, and we had to follow that curve, we had to follow the curve of the samples very closely, and so, taking only one or two samples, we could not make any calculations of that run of any accuracy at all, and I think that was the last Menaul run that we made in which we took only one or two samples for iron.

Mr. Wiles: Doctor, when you said you showed much less corrosion than shown in your report, you mean much less than the blanks? A. It shows somewhat less than the blanks. I don't know. You couldn't figure it accurately because we didn't follow the iron content in the sample. It is just an approximation. We made some blank runs later on these two sets of tubing, which we used in our report, and those runs dissolved 800 to 1000 grams of iron, somewhere in that order. This run, taking, even if you take those few determinations of iron in the tank and tube, which we found was not sufficient to show the content of iron in the tank, and figure it, it would be somewhat less than the amount of iron that went into solution in this particular run, and we explained it by means of metals that dissolved into the acid.

Mr. Lyon: Have you any figures in connection with this run B, how much lead or copper or iron was picked up by the acid in the tank?

Mr. Lightfoot: Maybe if we can look through the book.

Q. We will have to find that our later, because we can't stop to look through this book now. Now, the next entry in this DX-190 commences at page 46 and is entitled "Run No. C, December 21, 1939," that is correct, is it not? A. I don't recall the dates or anything else.

Q. And that entry, or the data on that run covers through page 53, and is signed by Mr. Lightfoot. Can you tell me—to shorten the matter, the data on that run, which is the first run used, first run in point of time? A. Yes.

Dr. Carl F. Prutton

Q. Which is used in either Exhibit 184 or 185, is reported run 1-M in Exhibit 185, is it not? A. This is the Menaul test. Yes, that is correct.

Q. This run at page 46, under the title of "Conditions of equipment, item 3," reads as follows: "Tubing is grounded at the end to a water line and insulated at all other points of support." What was the purpose of grounding the tubing at the end to a water line, do you know? A. Yes, very definitely. In a well the tubing is grounded, and we wanted to ground that particular tubing to simulate as close as we could the electrical conditions in a well. The tubing is grounded and the truck tank is not grounded, because it is usually on a truck that has rubber tires to insulate it from the ground. We supported our steel tank on dry boards, several of them, to keep them off of any conducting material, to insulate the steel tank from the ground, but the tubing was grounded.

Q. And why did you insulate the tubing at all other points of support? A. That I can't tell you, but it is immaterial so far as any electrical action is concerned.

Q. Well, it is not because that is the condition in an oil well, is it? A. I don't know why they did that. I didn't give them instructions to do that. I had told them to insulate the tank and to ground the pipe, and they probably figured, well, if he wants the pipe grounded, we will ground it, and they wanted to know where they should connect the ground wire, and I think I told them the bottom end, but the rest of it, why—

Q. (interrupting): Had you given any thought to the possible effect of grounding that pipe at the bottom and insulating it at all points with respect to the matters we were taking about yesterday as to the potential at the bottom of the pipe? A. I don't think it would make any difference.

Q. Have you considered that? A. Oh, certainly, certainly.

Q. You don't think it would make any difference? A. That is right.

Dr. Carl F. Prutton

Q. What about stray currents? A. Stray currents, you mean from the ground? Well, if we had stray currents that would need any protecting, or anything like that, or the reverse, we would have found them in these runs.

Q. How do you mean, we would have found them? A. We would have found the inhibiting effect, if it was an inhibiting effect, or corrosive effect, we would have found them. We wouldn't have been able to have checked within about ten per cent as we have. There would have been tremendous effects, if there was any stray currents.

Q. Did you find any? Did you test for them? A. No.

The Court: What do you mean by stray currents? A. Stray currents, if there are differences in potential in various parts of the earth, and different structures in the earth, and due to these galvanic cells, or due to the loss from power lines, and so forth, leakage occurs and there are minute currents that migrate around, but if when you have a well grounded insulation, such as a water system that has about the same potential as the earth, and there is very little chance that you are going to get any particular current, or any current flow due to stray current action.

The Court: Just where is it grounded in an oil well? A. Well, the tubing goes down through a head, and the casing is in contact with the earth and is grounded all the way down, the earth or cement, which is grounded, and the tubing is connected to the casing up near the top of the tubing.

The Court: And then the grounding to the tubing is at the top? A. Well, it is, yes.

The Court: And from the tubing this would be—this would run back up to the top and over to the casing? A. That is correct.

The Court: And then from the casing out into the earth all the way around? A. Yes, that is correct, but what we were doing—I don't feel that it makes any difference—

The Court: Is this the theory, that the tubing hangs

Dr. Carl F. Prutton

down into either space or into water or into oil? A. Down in the well.

The Court: And that is not grounding? A. Well, sometimes it may rest on the ground, but usually it does not.

The Court: You don't call it grounding because it touches this fluid, whatever it is—that would not be grounding? A. Well, it would be grounded somewhat if there were acid around it in between the casing and the tubing, and there would be—if there would be under certain conditions you would have a grounding effect there; but the conductivity of the steel is so great—the electric conductivity, that if you ground a piece of steel, you do not have to ground a particular corner of it. If I have a plate, or a piece of steel, and I want to ground it, I can put a wire at the plate, at any point, and the whole plate will be grounded, because of the conductivity.

The Court: The entire casing being grounded, and the casing being metallically connected to the tubing, the entire tubing is grounded? A. That is correct.

Mr. Lyon: The next test, or, the next run that was made is the one recorded commencing at page 54 of PX-190, and continuing through page 61, under the title of run D, dated January 5, 1940. This run is reported in Exhibit 185, under the designation 2-N, is it not? A. That is correct, yes, sir.

Q. The next run that is reported in PX-190, commences on page 62, and continues through page 69, and is signed by Mr. Lightfoot, and is entitled "2-B, dated January 13, 1940." Now, were the results of that run reported? A. They were not reported.

Q. Were they reported in either Exhibits 184 or 185?

A. They were not reported.

Q. This was a run made with the Menaul tank, was it not? A. Yes, sir.

Q. And using the same type of apparatus that is diagrammed in Exhibits 184 and 185? A. That is correct.

Q. Under page 65, under the title "Conditions of

Dr. Carl F. Prutton

test," it reads, (reading): "15 per cent hydrochloric acid, to be passed from stoneware crock into the steel tank, and directly through the piping system; the temperature of the acid to be 85 degrees F.; the hydrogen is to be vented at the tee. The rate of flow of the acid through the tubing is to be one gallon per minute. The tank and the tee are connected by an electrical conductor copper wire. The tubing is not to touch the tank." Is that a description of the test? A. It is similar to test B, but it was run with different tubing, however.

Q. Pages 66 and 67 show a complete table of the results of those tests? The actual measurements made? A. It shows some of the measurements.

Q. And the first column is time, and the test started at 12:42 and continued through to 10 minutes after 4:00. A. That is probably correct, if it is down there, yes.

Q. And why did you discard the results of this run, 2-B? A. Because for the same reason we discarded B. We got the same results. We got a reduction in corrosiveness and we found that was due to metals that were picked up in that short time of contact in the tank. The acid was in the tank an average of an hour and a half, as I explained before, and our analyses of the acid leaving the tank showed it had more than two parts per million of copper towards the end of the run. And the loss of iron, even so, was—the actual amount of iron dissolved was 490 grams. It was right in between the blanks and the ones made with the Menaul process proper.

Q. Now, I will try to speed this up. The next run that appears in PX-190, in order, was dated February 5, 1940; and is run A and is reported between pages 70 and 77, and that is the run referred to in Exhibit PX-184 as Run 1-AA, is it not? A. That is correct.

Q. And the tubing used in that run was the tubing used in Run No. C? A. In Run C, that is correct.

The Court: Read to me what he says about the description of the test, like you did in the other.

Mr. Lyon: Conditions of Test, page 73: "Fifteen per

Dr. Carl F. Prutton

cent hydrochloric acid to be passed through the tubing system from the stone crock. Rate to be 1 gallon per minute. Temperature 85° F. The acid contains no added inhibitors." This was a test without the steel tank.

The Court: Will you read it back. I am sorry to bother here, but back in 2-N, what does it say back there about it?

Mr. Lyon: I think page 57 is what I should read in response to Your Honor's question, instead of page 65. This is 2-N. Conditions of Test: "Fifteen per cent hydrochloric acid to be passed into the steel tank and to remain in the tank for six hours with mild agitation."

The Court: I think I find the same thing on 1-M, probably; is that right?

Mr. Lyon: I think so. I will try to find it for you. Conditions in test of 1-M are reported on page 49 and read "15% hydrochloric to be passed into steel tank and to remain in tank for six hours with agitation."

The Court: That's all. You have answered my curiosity.

Mr. Lyon: Now, the next test in order is dated March 17, 1940, entitled "Run F" recorded in PX-190 commencing at page 78 and through page 95 and is referred to in exhibit PX-184 under the two designations of 1B, is it not? A. F is 1B in the report.

Q. The conditions in that test as stated on page 81 are as follows: "15% hydrochloric acid containing PbCl_2 CuCl_2 FeCl_2 so that concentration is similar to that obtained in run C after acid had stood in the tank for over six hours, to be passed directly from the stoneware crock to the tubing system. The tubing was that originally used in C. The temperature is to be 85° F and the rate 1 gallon per minute." A. That is correct. That was a synthetic mixture we ran directly from the stone crock.

The Court: That was run directly and was discarded? A. No, sir.

Q. We have two exhibits, PX-184 which I understand has no Menaul tank runs, all just runs from the stone

Dr. Carl F. Prutton

crock into the tubing, and PX-185, which reports the runs through the tank.

The Court: Is this right from the crock to the tubing?

A. Yes, sir. The synthetic acid to which we had added the metals.

Q. Through each of these runs where there is a Menaul tank we found this same statement—that the tubing was grounded at the exit end, insulated at all other points. A. That is true in all the runs.

Q. The next run is dated April 6, 1940, and is entitled in Exhibit DX-190 Run G, pages 86 to 93, and that run is referred to as 1A in PX 184, is that correct? A. That is correct. That is another stoneware to tubing run.

The Court: Crock to the tubing?

Mr. Lyon: Yes, sir. The next run reported in DX 190, pages 94 to 101, as run H, dated April 13, 1940. The conditions of test of this run as reported on page 97 read as follows: "15% hydrochloric acid would be passed into the steel tank and to remain there for six hours with mild agitation. Then to be run through the tubing system at 1 gallon per minute at 95° F., the hydrogen to be vented at the tank and the T to be connected by an outside electrical connector. Tubing is not to touch the tank." There is a table and the results of that test on pages 98 to 99, and that test is referred to in Exhibit PX-185 under the designation 2M? A. That is correct.

Q. The next reported test in DX-190 commences at page 102 and continues through page 102 and continues through page 109, dated April 18, 1940, entitled "Run I." The conditions of that test as given on page 105 are as follows: "15% hydrochloric acid containing PbCl_2 CuCl_2 FeCl_2 —so that the composition of the acid is similar to that in Run H—after the acid had remained in the tank for seven hours, the acid to be passed directly from the stoneware crock through the tubing system. * * *" A. This is the synthetic mixture with the acids introduced, run directly from the crock to the tubing.

The Court: They are doing in the crock what they contend has happened in the transportation tank?

Dr. Carl F. Prutton

Mr. Lyon: That is correct. "The acid to be passed directly from the stoneware crock through the tubing system. The tubing used was that previously used in D and H, the temperature to be 85° F., and the rate of the acid through the tubing 1 gallon per minute." There is a table of these results on pages 106, 107, signed by Mr. Lightfoot, and I will ask you whether these results were reported or given effect either in Exhibits PX-184 or 185? A. They were not.

Q. Why not? A. Well, the first thing when we completed the test and had our analytical work completed, which was some time after the test had been completed, we found that there was considerable discrepancy in the copper content of the inlet acid which was, as I recall, pretty close to 3 or 4 parts per million, but the exit acid analyzed (and we had a number of analyses on the exit acid) showed a figure of about 1½ or a figure of that order. Then we had run inhibition on the inlet acid and it ran very much lower. In the laboratory inhibition test no acid with that amount of copper was run. We didn't have enough sample left of this particular run to reanalyze and redetermine the inlet copper. The only thing that we could see was that something had happened in there that the weighing out of the copper salt or something that had produced some peculiar effect and we dropped that one out. We did not have enough.

The Court: It did show less copper than the other? A. Yes. The exit acid from the tubing was very low, but the inlet acid analysis that we ran, the first one showed it to be high, three or four parts per million, as I recall, and the inhibition that we ran on the inlet acid—we ran it in the laboratory test—was about half of what we got on other samples that had the three or four parts per million of copper and lead in it; and, therefore, we believed that for some unknown reason the copper content of the acid was not correct, and not having enough samples to go back and run the inlet acid over again, we decided that we would not report that result.

Dr. Carl F. Prutton

Mr. Lyon: How about the actual amounts of corrosion, the dissolved metals, as reported in the different measurements in this test, compared with other tests? A. I believe the corrosiveness was fairly high. It was about—

Q. Will you examine this and see (indicating)? A. I cannot tell from the figures. You have got to calculate it. You have got to take all these figures and make your calculation. You remember about what it was, Bill? Was it 500 grams, or something like that?

Mr. Lightfoot: I don't know, but I can calculate it.

Mr. Lyon: Was it lower or higher than other tests? A. I don't know. I don't remember.

The Court: Let me ask you this question, if all your tests had been comparable to this, and had run like this, would the results have been more favorable to Halliburton and less favorable to Dow? A. It would be more favorable, definitely to Halliburton, but still that wouldn't change the degree, it wouldn't change the picture, but—

The Court: I just want to get it squarely on the record, and in my head, that these were some results that would have been more favorable to the other side, if correct? A. If correct, yes, and we have all the figures there that they can see.

The Court: How much more so, speaking generally?

A. Well, that I cannot tell unless we have got all of the figures.

Mr. Lightfoot: The iron was in the 400's.

Mr. Lyon: As compared with 1000 for the other tests you reported? A. The blank was 1000, the uninhibited acid, and this acid which was made up to duplicate some of these tank truck acids with lead and copper ran about 400, or maybe between 400 and 500, according to Mr. Lightfoot, instead of two to three hundred that we reported on the other figures. In other words, instead of an inhibition of 70 to 80 per cent, it would have been 60 per cent, and we had an explanation for that drop.

The Court: Now, let me ask you this question: What do you think if this had been, this one, had been as much

Dr. Carl F. Prutton

more favorable to Dow and unfavorable to Halliburton as it was favorable, do you think you would have discarded it entirely under all of the circumstances, or do you think you would have reported it for whatever it was worth, what do you think about that?

Mr. Lyon: I would ask him to remember run 2-A which said report shows about the same amount out of line in favor of Dow, when he answers that question. A. Well, I think that this is further out of line than any of the things reported, and some of the others are out of line, I will grant you that, and regardless of the—when you look over a series of data, if you see one of them more out of line than others, I think you are permitted to drop that, particularly if it doesn't change the over-all picture.

The Court: Is this more out of line in favor of Halliburton than some of those recorded, I mean the others recorded are out of line the other way? A. Well, as I recall this is more out of line. And you can't—you have to look at a whole series of numbers to figure out whether it is out of line or not, and it is difficult to put your finger over one definite thing and say that that is the thing that determines whether it is out of line.

The Court: The question I have just asked is largely the substance or purpose of going into all that? A. Yes.

The Court: I thought I would go directly about it and not beat around the bush at all.

Mr. Lyon: All right. Now, as a matter of fact, compare the amount that run 2-E, which you reported in Exhibit PX-184, with this particular run that you have just been asked about, and tell me how much more this run is out of line than run 2-E is out of line? A. What is 2-E? Let us get the book.

Q. 2-E is out of line in Dow's favor, and I think you mentioned it yesterday as out of line. A. I think in my testimony I have indicated that in running a large scale set-up like this that there is certain leeway, and I have indicated this 10 per cent and so variation. I don't believe that you can run a large scale practical test, or make it prac-

Dr. Carl F. Prutton

tical and get the fine exactness that you can get in a scientific laboratory with a gram of material, and I have indicated that, and if this would have changed completely the picture I would have studied that to the nth degree. The picture we have presented, this does not change the picture one particle.

Q. I am not asking you that, and I object to the witness arguing on cross examination, Your Honor. I have asked him to compare run 2-E which he did report in PX-184 in which he has admitted already out of line in Dow's favor, the amount that that is out of line with the amount he says his tests we have just been inquiring about was out of line in Halliburton's favor. A. 2-E. It is out of line in the fact that it showed a lower amount of corrosion. But I don't recall any of the things that you determine in throwing the test out. Those are the things, when you collect a whole bunch of data and figures and you pick one and use it, you find some holes in that data, and then you find the differences and discrepancies in these, sometimes you throw out the final answer and the whole thing.

Q. I am not asking you that. I am asking you to point out, the point of my question, is Exhibit 2-E any more or any less out of line in this report than this test we have referred to in Exhibit 190 which you threw out? A. All of the work, as I recall the data that we took, the evidence indicated that 2-E was a valid run and I reported it in No. 1.

Q. I am not asking you that. Is it out of line compared with the other? A. Out of line in what way?

Q. With the results of other tests you included with it, by as big a margin as the figures of this discarded test? A. If you take that view of it, no.

Q. How near is it? A. I would say that the Menaul tests in these synthetic acids—

Q. (Interposing): I am talking about 2-E. 2-E. A. That is right. If I am saying something is out of line I have got to compare it with something it is out of line with. About the average of synthetic acids in the Menaul tests

Dr. Carl F. Prutton

might be 250 grams of iron dissolved, somewhere in that range. Very close to it. The synthetic acids in the Menaul tests all showed about 250, and the blanks 1,000. This was 101.4 grams from our analyses. That is a difference of 150 grams, from 250.

Q. How much per cent is that out of line from 250? A. Well, now, I say it is 150 grams of iron different.

Q. Then out of 250 it is 150 off, is that correct? A. It is off, if you take the averages of different kinds of tubing and the tests made, the average of averages.

Q. You have given the figure 250 as the proper starting point now, and this result which you reported in 2-E in Exhibit 184 is 101. A. Yes.

Q. Therefore, it is about 150 out of line from 250? A. That is correct.

Q. And you reported it? A. I reported it.

Q. All right. Now, how much in figures was the Test I in Exhibit 190, which you have referred to and which you threw out, out of line? Give us the figures? A. If it was 400 to 500, why it probably was—

Q. (Interposing): I didn't say "if." What are the figures? A. I don't have them.

Q. You gave the judge a direct answer a few minutes ago. A. I did not.

Q. To his question? A. I gave him 400 to 500.

Q. It was an important question, I thought. Now, what are the figures? Let's see if you are justified in your answer as to why I, being more out of line than Exhibit E-2 which you included. I want to know what the figures are. A. The answer that I gave the judge was based and the discussion that I had with the judge was based upon the numbers that we accumulated in getting this final calculated result. That question was whether the conditions were more out of line and the test was more out of line than the one which we incorporated, any one we incorporated in favor of Dow, and I say that the analytical figures as we went along indicated that there was something wrong with this work.

Dr. Carl F. Prutton

Q. You refuse to answer my question? A. No, no; I have answered your question.

Q. Answer it. A. But I refuse to answer the question to imply that I answer wrong to the judge.

Q. Just answer my question, if you will. A. I did not give the judge and I did not give anyone a definite figure for the amount of iron dissolved in this particular run. I said that according to Mr. Lightfoot it was 400 to 500 grams of iron dissolved, and if you take this figure of 250, the difference would be from 150 to 250 grams.

Q. I am not asking you that. If you will answer my question and stop arguing, why, we will get—avoid any misunderstanding. I asked you to give me the figures for the Run I which was discarded, what the starting figure is for comparison that you think is in line with the actual figure that you got in Exhibit I. I want to know how much it is different. A. I do not have the figure.

The Court: Where are they? Aren't the figures here? A. I don't think that we have them calculated. When we found that these analyses were off, I don't think we went through, and we kept that—

Q. (interposing): Doesn't Exhibit I—doesn't the data in DX-190 on Exhibit I show that 670 grams of iron were dissolved? A. I don't recall that it does.

Q. Will you look at it? It is right there. A. Will you look at it? (to Mr. Lightfoot).

Mr. Lightfoot: You mean this?

A. (After conferring with Mr. Lightfoot): The figures that are given in the book there on the iron content of the solution were run by an analytical procedure that is known as the gravimetric method for iron; and we found out after we had run a number of tests, that that method could not be used in the presence of lead, and this run had lead in it. The samples were taken and run for iron by a method which we verified in the presence of lead, a volumetric method, the dichromate method, and the analytical figures—I am not sure that we have them on this particular run, we had thrown them out on the basis of the figures or

Dr. Carl F. Prutton

analysis during the run, and I don't know whether we have the figures on this new method of iron analysis, but if we do, we can make the calculations.

The Court: When you started to make that run, you knew that there was lead in it, did you not? A. We knew that there was lead in it.

The Court: Didn't you know that you had a method that you could choose where you had lead in it? A. The method—we had samples that contained different amounts of lead. We had raw acid that had very little lead in it, and the gravimetric method there worked very well with the small amount of lead, but in some of these samples where the lead went up high, the gravimetric method would not work.

The Court: Is that something that was learned in this very experiment, do I understand? A. No, not in that very experiment. I don't recall exactly when it was learned.

The Court: I don't get the point. A. Well, the point is—

The Court: That you started this because you had used a method that was not applicable? A. No, no. We had analyzed for copper in the samples of acid, and we had analyzed the original acid for inhibition in the laboratory tests and we found that gave a very low inhibition and the analysis of the effluent acids, which was very low in comparison, which was not found in the other runs, and we decided that there was something wrong with that test, so we discarded it. Now, we subsequently learned that the method that we had used for determining iron was not only taking down the iron, but taking down some of this lead, and we ran all the samples that we could get to determine the iron by this new method, and this run which we had discarded, I am not sure we ran over again for iron. Do we have those figures?

Mr. Lightfoot: Yes.

A. He said we have them, so we can calculate this exactly, and we will do that, if you want it.

Mr. Lyon: I certainly do. A. Will you make a note to that effect?

Dr. Carl F. Prutton

Mr. Lightfoot: Yes.

Mr. Lyon: The next run in this book is run J, dated April 26, 1940, reported in PX-190, commencing at page 110 through page 117. A. That is 2-B, run 2-B in the report.

Q. And the next run reported in PX-190 commences at page 118 and runs through page 125 and it is dated April 30, 1940, and is entitled "Run K," and that is referred to in Exhibit PX-184 as run 2-A? A. That is correct.

Q. Then the next entry in PX-190 is directed not to further runs, but to what are entitled "Changes in procedure for chemical analysis"? A. That is correct.

Q. And they cover from page 126 to page 130 and are then followed by the entries of various actual chemical analyses determinations up to page 157? A. That is correct.

Q. Now, various of these chemical analyses which you reported at this point in PX-190 bear notations such as the one on page 131, which is entitled "Iron analysis," and you have written there "Not used in report." Did you make the decision not to use these various results as indicated in Exhibit 190 in the report? A. I think that is my handwriting. I am quite sure it is.

Q. Then we have another one on page 133 entitled "Chemical analysis, run 2-B, methods and results discarded," that is correct, is it not? A. Yes. Run 2-B is the one that we ran the acid through the crock or tank and then out.

The Court: Now, this is showing that—have you referred to another one there too?

Mr. Lyon: There was run A, it says "Not used in report," page 131. The item on page 131 there refers to run A. The item on page 133 refers to run 2-B.

The Court: What is the date of the one you called A?

Mr. Lyon: Run A—the first run in the book, November 24, 1939. That was not used.

The Court: Now I have got just three that were not used.

Dr. Carl F. Prutton

Mr. Lyon: You have got A, B, 2-B, and I were not used. A. Four runs.

Mr. Lyon: A, B, 2-B, and I. If you want the dates of those, run A was November 24, 1939, run B was December 16, 1939, run 2-B was January 13, 1940, and run I, April 18, 1940.

The Court: I have got it right now.

Q. Now, then, the next we have, commencing at page 135 of PX-190, the chemical analyses for run C, which run was dated December 9, 1938, and is run 1M in Exhibit 185. We stop making runs in this book and make chemical analysis.

The Court: Let me call attention to the fact B is the one I have used more than once. I have 2B not reported. That is the only time I have used one letter more than once. And neither B was reported. B wasn't reported and 2B wasn't reported.

Mr. Lyon: That is correct.

The Court: Now, I haven't in my mind the relation. We start a series of letters—A, B, C, and D. They bear some relation to each other. I haven't in mind the relation between B and 2B.

Witness: B was run with acid going into the steel tank, immediately out. 2B was run in exactly the same way. The same letter was used to designate the same type of run.

The Court: The same in every way? A. Excepting the tubing was different. Isn't that right?

Mr. Lightfoot: Yes.

The Court: You not only ran them in the same way but got—

Witness (interposing): —the same general results.

Mr. Lyon: Now, Your Honor, at that point in Exhibit PX-190 the entries take up the change in analytical methods and record chemical analyses, the results, and later as we will see, they take up additional subsequent runs. Beginning at page 135 under the title "Chemical Analysis Run C" are the results of chemical analysis on run C; and the

Dr. Carl F. Prutton

first values are given as item No. 1, entitled "Iron analyses," run 12-28-39; and there is a notation here in pencil. Your Honor, all of these entries are all in ink—I haven't stated to Your Honor that all of the regular entries in PX-190 are in ink, but some of these notes are in pencil. In the margin is written, "Results not used in report." Is that because you had to recalculate these results by some other method? This is entitled "Iron analyses gravimetric method." A. We did not use the gravimetric method in the report. I told you that the gravimetric method was used on some samples, and then we repeated and re-ran those samples with the volumetric method, which is the accurate method, and so we did not use those, and, as I recall, I went through, and where we had used the gravimetric method—

The Court (interposing): Did you know before you ran them that one was an accurate method, and the other not? A. No, because iron and lead is a rare combination to get together in a solution, and the methods that I have described in the determination of iron—in most of the text-books, they do not mention that lead is an interfering element, and it did interfere to some extent.

The Court: But did I understand you found out as a result of these runs and the experiments and analyses that it was inaccurate, in the reports? A. Exactly. The reason it was found out was this: These men that were running the analyses, the final determination is that you weigh up iron oxide after precipitating it out of solution, and iron oxide is red like iron ore and should be fluffy and hard, and I noticed on some of these samples, I just happened to pick up the crucible and inspected it and noticed that the iron oxide had become fused into the porcelain of the crucible, and iron oxide will not do that at the ordinary temperature of ignition, but lead oxide will do it, and, therefore, I suspected that some of the lead was coming down with the iron and gave us a high result on the iron, so we took the volumetric method and made up standard solutions of iron and iron containing lead and determined that

Dr. Carl F. Prutton

we could accurately find out the content of iron in the solution by that volumetric method, and we repeated all the analyses.

The Court: What I wondered, is that some information now that you can apply to all other tests all the rest of your life, that the one is accurate and the other not accurate, or does it simply mean that for this particular test it is. A. (interposing): Oh, no.

The Court (continuing): — it is not accurate. A. We used this volumetric method for every iron figure that is reported with the exception of one or two figures that are run by the gravimetric method for the raw acid or acid that did not contain lead. There are a few of those gravimetric figures that we did not re-check because there was no lead in the solution, and we know that that is an accurate method when there is no lead in the solution.

The Court: Why use the gravimetric method at all, ever again, then? A. Why, we had started out with the gravimetric method, and we are not going to use the gravimetric method in this book from then on.

The Court: I know. But are you ever, as long as you live? A. Oh, yes.

The Court: I am wondering whether it is something that is not an accurate method or— A. (interposing): No.

The Court (continuing): — whether it is simply something in connection with this. A. In connection with this case, the fact that lead and iron were both present in solutions, and there was an appreciable amount of lead in solution was the thing that made that method inaccurate for the determinations. If lead had not been present, if it was just iron and copper—

The Court (interposing): But you knew lead was present. A. We knew lead was present.

The Court: Well, did you know that when lead was present that the gravimetric method was not accurate or did you first learn that in your lifetime there? A. I am just trying to figure out how the method of analysis was started in. You see, I had two men that did my chemical

Dr. Carl F. Prutton

analyses, Reihl and Halverson, and as I recall it we had samples of the raw acid that had practically no lead in, and I told them in a brief discussion to use the gravimetric method, without any great amount of thought about the lead, and I think that if I would have given it any serious consideration, looked it up thoroughly in the literature, I would not have told them to use that method, and when I saw these fused precipitates I knew that they did not have pure iron oxide, and the method was not working, and then we went back and I personally ran about 90 per cent of all those iron determinations by the volumetric method, and the others reported are by the volumetric method, which we have proven to be accurate.

Mr. Lyon: The next item I call your attention to is No. 3 at the top of page 136, entitled "Chemical analyses, Run C, continued, lead analysis," which was run on 1-10-40, and a legend reads, "Crock comp." What does that refer to? A. I would think that would mean composite, is that correct?

Q. That means this synthetic composite of the crock?

A. Yes.

Q. And the value of that in milligrams of lead per c.c. is .0059. Then the next item is composition of tank and the value is .39, and then the composition of the end is .49. What do those values indicate? A. They indicate that in this—that was run C, wasn't it? The crock acid was commercial acid diluted to 15 per cent with tap water, and that very low figure for lead is the lead content of that acid, practically no lead in it. Then the composite of the tank samples are the samples that were taken from this Menaul tank during a run and were analyzed and showed .39 milligrams per c.c., as you read it there. The acid leaving the end of the pipe was analyzed and showed .49 milligrams per c.c.

Q. That is correct. Now, does that indicate that the acid in its progress down the pipe picked up some more lead? A. No, it doesn't indicate that at all. It indicates what I have explained to you before, that in this Menaul

Dr. Carl F. Prutton

tank that lead chloride, when this sheet corrodes in the acid the lead forms lead chloride, and that lead chloride becomes some dispersed in the acid at the bottom, the acid in that tank during a run, which is not stirred, during a run was just drained down, when you dip the bottle into that tank the most concentrated acid is down near the bottom and it is from the bottom that the end of that tube, the tubing system is sucking the acid from the top of this lead plate where the concentration is greatest, and therefore it is logical to expect that the effluent acid which is being taken always from on top of that lead sheet, being sucked very close to the lead sheet, would be greater than samples you would obtain by dipping into the tank. And the other thing is if we had felt that was of any major importance, we would have made much greater investigation than we have of that.

Q. Isn't your statement a mistake there was no agitation in this run C because if you refer back to page 49 under the conditions of test run C don't we see that "15% hydrochloric acid to be passed into the steel tank to remain in the tank for six hours with mild agitation"? A. There are two steps there—three. You take acid from a stoneware crock, run it into a Menaul tank, then you spend six hours and occasionally stir the acid. You get agitation then. When the run starts, you don't stir it. The only agitation you get is by the 1 gallon per minute of the acid being sucked into the tube; so during the test there is no agitation.

Q. But during the six hours there is. A. Yes, but the samples of the inlet and outlet are taken during the test.

Q. In stating the composite of the tank was .39 and the composite of the outlet was .49, does the latter refer to the analysis of the material as it comes out of the bottom of the tank? A. The .49.

Q. Now, then, the lead content of the acid as it went into the pipe at the top was .39 and as it came out it was .49, wasn't it? A. I explained to you that that wasn't the case.

Dr. Carl F. Prutton

Q. I don't understand the explanation. A. Here you have a steel tank with some hydrochloric acid in that has been agitated for this six hours occasionally. During that time the lead sheet has corroded and formed lead chloride and some copper chloride. The lead chloride doesn't all go into solution and be evenly dispersed in this acid. There is some lead chloride of a thin whitish film on the lead plate. The lead chloride on the lead sheet which, of course, is being continually formed, and the loose particles which is dispersed not dissolved then tend to accumulate in the bottom of the tank; the concentration at the bottom when you let it set is greater than at the top. When we took samples of the composite of the tank we dipped into the tank and took the sample. The tube which is delivering the acid out of that tank was just an inch or two above that lead plate, so it was sucking acid by that lead plate, and naturally would have a higher lead content than samples we dipped out of the top or dipped out of the middle of the acid. That is why the exit acid in this run is higher than the inlet. As I said before, the reason it didn't disturb us much was it was very easy to see this lead chloride that we have shown and other people have shown, that the amount of lead in the range of .39 or .49 is substantially the same as an inhibitor.

Q. Well, then, you don't have an actual figure here for the lead content of the acid as you put it into the top of the pipe? A. I didn't say that. I believe the stuff coming out the bottom is substantially the way it went in.

Q. I am not asking you that. You don't have an actual figure— A. (Witness interposing): Of the analysis of the lead content going in. We do not.

Q. Do you have a figure for the actual lead content of the acid introduced into the top of the pipe? A. For all practical purposes the .39 is a good figure and .49, or an average, any way you want to take it.

The Court: What I understand you to say is you think it is higher in lead. I don't think it makes any difference but you think it actually is higher in lead content

Dr. Carl F. Prutton

than the average of the whole thing. A. At the bottom, right at the lead plate.

The Court: I say that you put in— A. (Witness interposing): Yes, that is correct.

Q. (By Mr. Lyon): Is that true of the figures you have reported PX-184 and 185 as to the lead content of the acids introduced into the top of the pipe? Are they subject to that same correction? A. I don't know what the figures are. I would have to see them.

Q. You know the figures, don't you, in Exhibits 184 and 185? Maybe you better take a look at them. Figures for the synthetic acids and the figures for the tank acids where you have given the lead contents, and tell me whether they are subject to this same explanation that you have given here? A. (After examining documents and books): We will have to get it out of the book. It is not in the report. Do you want us to go through the book and get the figure?

Q. Don't you report in Exhibits 184 and 185 that these were the amounts of lead that you found in the tank acids or the composite acids? I am talking about the inlet? A. Oh, the inlet?

Q. Yes. A. The figures are given in the report.

Q. Well, now, are they subject to the same explanation and correction that you have referred to in connection with this figure of .39, or did you use these figures— A. (Interrupting): I don't think you would get the same difference in runs—you might—if this pipe were right down on the lead sheet, you would get quite a bit of iron in the effluent acid. If the pipe were to—

Q. You must have misunderstood my question, because you are not answering it at all? A. I did not understand it then.

Q. You reported in Exhibits 184 and 185 figures of the lead content of the acid that was introduced into the top of the pipe? A. That is correct.

Q. Did you use these figures that I have been referring to in Exhibit 190 without correction, or did you correct

them in any way to take care of the feature that you have been referring to?

Mr. Wiles: You did not mean to include the exhibit that had the synthetic acids in it, because this factor does not exist there at all. There is nothing about synthetics.

Q. Well, I don't know about that. Well, all right, let us limit it to the Menaul acids. A. The figures that we reported in the report are the analyses of the samples that we dipped out of the tank.

Q. You did not make any correction? A. We did not make any correction for the effluent concentration.

Q. Let us refer to the next item No. 4 on page 136 of this chemical analysis for run C. This is entitled "Inhibitions, small metal samples, sample, weight, loss, inhibition," and there is the series from C-1 to C-8, and the weight losses are given. The inhibition is expressed in grams, meters per hour—I think that is meters, "Grams m. per hour"? A. I think it is meters.

Q. And the per cent is given, and for C-1, there is no per cent. For C-2, it is given as 28.5; for C-3, it is 32.0; for run C-4, it is 33.6; for C-5, it is 33.3; for C-6, it is 29.3; for run C-7, it is 28.6, and for C-8, it is 34.2. Then there is a marginal note in pencil, "Not used in report." Now, will you explain that table, and explain what the tests were, what these percentages are, and why you did not use them in the report? A. When we started in with this work we knew that Dr. Bartell was employing a small specimen in an inhibition test and a small volume of acid, and we used that in measuring the inhibition of acids in some of these tests as reported here. And the inhibition of our commercial acids all ran about zero or very close to it, within a few per cent of zero, on the same small test. And the inhibition of these synthetic acids or Menaul acids that we ran all ran around 30, between 30 and 40, which is very similar to the results Dr. Bartell got on the field samples that they had obtained.

But when we ran it through the big tubing here we got 70 per cent inhibition. And the thing that we couldn't ex-

Dr. Carl F. Prutton

plain was the difference between the inhibition obtained in those small scale tests and in the large scale test. We then thought that the results were probably due because the cutting of the little piece of metal used to work it and deform it a great deal, and therefore you have got a peculiar surface, the volume and the time in contact, and so we went to the method that we used in our subsequent inhibition tests for laboratory purposes.

We simply took a piece of actual tubing and we gave it the same type of cleaning as the tubing got in the large scale tests, and we used the same mass or volume of acid and area in contact with the acid that we used in the large scale tests and used the same time of contact that we did in the large scale tests. The only thing we couldn't duplicate was the agitation. And then we got very similar results in the laboratory and in the large scale tests.

And so in the small scale tests the inhibition there says "Do not use" simply because I don't recall that we reported any inhibitions in the report except this large scale, the one with the one inch collar of iron, of oil well tubing, the second laboratory test which we developed which gave us correlation with our large scale tests.

Q. Are these small scale tests that you refer to all these tests made with these samples? A. Made with the small specimens.

Q. They were made under laboratory control conditions, were they not? A. Yes, they were controlled.

Q. Carefully made? A. Well, I would say they are fairly carefully made, yes.

Q. Well, now, they all showed very much lower percentages of inhibition than the tests that you reported in Exhibits 184 and 185? A. That is correct.

Q. And you continued to make those tests of that kind and obtained those kind of results throughout all your work, did you not? A. No, sir.

Q. When did you abandon them? A. I don't recall when. Can you tell, Bill?

Mr. Lightfoot: I think starting with run 1-N, as listed in that book.

Dr. Carl F. Prutton

A. Run N in the book.

Mr. Lyon: When was run M made, can you tell us?

A. Yes, I can give you the date. M, 12-23-40, December 23, 1940.

Q. That was made a year after your run A? A. Yes.

Q. And you continued to make these laboratory tests for the per cent of inhibition of reduction of corrosion and obtained uniformly all these results down around 30 per cent? A. 30 to 40 per cent.

Q. And you excluded them all from your reports, reports to the court here, that is correct, isn't it? A. We excluded them all?

Q. Yes. A. Yes, because we had this correlation between the laboratory and large scale tests and we felt this large scale test was a very valid test, and therefore to get a test that would correlate in the laboratory we could study acids before we ran them in this large scale test, if we wanted to, and therefore we wanted a laboratory test that would give us a practical result that would resemble in some way what we got in the oil well tubing.

Q. I notice on page 145, PX-190, a table entitled "Inhibitors, inhibitions, runs A through G. These inhibitions were run on the samples on the modified method, using 50 c.c.'s of acid, suspending the sample by glass hook from the specially prepared cap." I don't know what that is. A. Cap, I guess.

Q. Cap time 16 hours, sample and location is the first legend, losses is the legend for the next column, area is the legend for the next column, inhibition is the legend for the next column, and per cent the last. I suppose that refers to the per cent reduction in corrosion? A. Well, I would think so. Let me see.

Q. The date says run 5-7-40. I am going to read you parts, giving just the identification of the samples, and their location and the percentage of reduction of corrosion. A. All right.

Q. Sample A, location Crock, per cent—(reading from table): A End Composite 6%; 2B Crock 0%; 2B Tank

Composite 9.6%; 2B End Composite 16.5%; C Crock 0%; C Tank Composite 28%; C End Composite 26.6%; D Crock 0%; D Tank Composite 34.2%; D End Composite 34.3%; E Crock 0%; E End Composite 13.8%; F Crock original—and there is a star here in the footnote saying “Not Run” “Use D as 42.0 the average of the crock original for runs A, 2B, C, D, E and G; sample of crock and metal percentage 21.9%. Then Sample 1 End Composite 26.0, Sample G crock percentage zero, sample G End composite 5.8,” and that is the rest of the percentages. Now, these samples designated, do they refer to the letters of the original runs as they were originally lettered? A. In the book.

Mr. Lightfoot: That is right.

Q. And the sample by crock means the sample was taken out of the crock? Mr. Lightfoot: Yes.

Q. And the end product means it came out of the tube at the bottom? Mr. Lightfoot: Yes, sir.

Q. The tank compound means the sample was taken out of the Menaul tank? Mr. Lightfoot: That is right.

Q. None of those results were reported in Exhibits 184, 185? A. No, because we felt those small tests did not represent what happened in an oil well tube.

Q. I am not going to take the time to point out the corresponding determinations and the results that were made with each one of these different runs. They are all here in the book, aren't they? Because your explanation covers them all. A. You mean the explanation of the small scale test?

Q. Yes, sir, as to why they were left out and they were left out. A. They were left out because we didn't feel that small scale test gave us a practical measure of inhibition. We ran the large test which we felt was much more comparable to certain figures, and we got the figure repeatedly in a total of eight runs. The second method of running the test in the laboratory we used the 1" pipe and gave results that compared close to the large scale flow tests.

Q. All right. That brings us up to page 156, because

Dr. Carl F. Prutton

I won't stop with the other analyses on the runs that have been performed up to that date. That brings us to a matter of copper analysis for runs K and L. You had to make a change in your method for analyzing for copper, didn't you, in the progress of this work? A. Yes, the method that was originally used for some of the earlier work was the method that we discussed this morning, earlier today, in the front of the book there. It was the first method received from Dr. Bartell and we learned that very shortly after he had sent us that method that he changed over to that other method he obtained from Dr. Willard. When we were apprized of that, we changed over and the figures reported in the report are all based upon this second method for copper.

Q. What did you do? Go back and re-analyze? A. Analyze all the samples we had to determine the content of copper.

Q. (By Mr. Lyon, continuing): Then, as a matter of fact, you originally analyzed these various samples from these various runs for both iron and copper by methods that you afterwards discarded, and you had to re-analyze all those samples by new methods, for their iron content and their copper content, is that correct? A. Not all of them; some of them.

Q. And that work of re-analyzing was done about a year after the runs were made, and after the original analyses were made, isn't that correct? A. That is correct. The results that were obtained, however, did not change the picture or the conclusions one particle. The analyses were—it was an academic study more than anything else. The loss in weight of the tubing that we calculated, and the per cent in difference that we found in the last were just within a per cent or two.

Q. When you say the results did not change, or that these differences in figures did not change the results, you mean within your interpretation of what the important result is; you don't mean that they did not actually change the figures supporting them? A. Oh, yes, they changed the figures. For example, when we ran a sample of acid

Dr. Carl F. Prutton

from the Menaul tank, it may have had one and a half milligrams of iron in it, and a half a milligram of lead in it; and we ran that by the old iron method, and we probably found 1.6 or 1.7 milligrams of iron there, a high result. That is in the Menaul tank. Now, in the effluent acid, we used the same method, and the effluent acid probably was $2\frac{1}{2}$ —let us say—or, two of the true value, and it had lead in it, and we probably found 2.1; in other words, both figures were up by the same amount, and although there was an error in the method, we got 1.6 milligrams in the Menaul tank, and 2.6 in the effluent. That is the difference which we used to calculate. The iron remained the same. And, therefore, after the iron had been repeated, the same conclusions were obtained, that there was 60 to 80 per cent inhibition in running the Menaul tank, the Menaul tank without wire, and the synthetic acids—the picture was exactly the same.

Q. Well, now, wait a minute. You say that the difference would remain the same, but the values were changed, raised or lowered as the case may be. A. Yes.

Q. Well, then, as you were reporting the results as a percentage, the change being a percentage of the whole, that would change that per cent. A. We don't do that.

Q. What do you do? A. We use the figure for iron in the inlet acid and the figure for iron in the effluent acid and take the difference to figure out how much iron has been picked up.

Q. But you report per cent of reduction in corrosiveness here based on those differences? A. No, sir; absolutely not. Those figures are not used for that purpose.

Q. Now, tell us about the copper. What actual difference in values did it make in these differences in the measurement of copper? A. As I recall the copper, the first method was the colorimetric method as well as the second, and the only recollection I have that was wrong with it was that it produced a color and that that color was fugitive. In other words, it would go away in time, and they had to adopt a standard procedure of just measuring

Dr. Carl F. Prutton

the color at the end of a certain time and that was not very convenient, and, therefore, there was a chance to make some little error there by the observer. And in the second method that color stayed and was quite permanent. Isn't that the main difference?

Mr. Lightfoot: Yes. A. That is my recollection of the two methods.

Q. Well, was there more than two methods? A. No.

Q. That you employed for copper? A. No, there was just two methods.

Q. You haven't tried any other method since? A. No other method for copper.

Q. I notice on page 156 a table entitled "Copper Analysis, Runs K and L, Carbamate Method." A. That was the second method.

Mr. Lightfoot: Yes.

Q. That was the method you actually reported? A. That is the good method, better method, of the two.

Q. That is the one you used? A. That is the one on which the figures are based, on the carbamate method. All the figures in the report are based on the carbamate method, as well as Dr. Bartell used that method.

Q. I notice on the left-hand side of this page a note, "Results Discarded." ~~But~~ on the bottom of the column it says "Above samples analyses enclosed with report but questionable due to color interference." Will you explain that in the light of your testimony? A. The analyst that ran these samples wrote along the side of them "Results Discarded. See page 154 for re-run." In other words, he must have noticed something was wrong or he did something wrong. "Above samples analyses enclosed with report but questionable due to color interference." "Above samples," that must mean these top ones. I can't interpret that last sentence there. Were these figures used?

Mr. Lightfoot: I don't know. A. I would like to have the book and take time to check it and find just exactly—

Q. (Interposing): You do that. We are going to

Dr. Carl F. Prutton

have two hours at noon, and I hope you can do it in that time. A. All right.

Q. It takes a long time to check some of these things. Now, the next entry in this book commences on page 158 and is entitled "Run L," dated May 11, 1940. And the write-up for that run goes through with the entry of results through page 165. And the Conditions of Test on page 161 are stated as follows:

"Fifteen per cent HCl to be passed into the steel tank and to remain there for approximately six hours with mild agitation. Then to be run through piping system at approximately one gallon per minute. The temperature of acid to be 85° F. Tank and T are not to be connected by any outside connection." And that run L is referred to in Exhibit PX-185 as run 1-N, is it not? A. That is correct.

Q. The next entry in the book begins on page 168, entitled "Run M" made December 23, 1940. The write up for that run continues through page 175 and the conditions of the test are stated at page 171 as follows:

"413 N HCl acid treated with $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ PbCl_2 and CuCl_2 to be passed from the stoneware crock at 1 gallon per minute at 85° F. through the tubing system." That run is referred to in PX-184 as run 2-D, is it not? A. That is correct.

Q. The next entry in the book commences at page 176 and is entitled run N, dated January 7, 1941, and the write up for this continues through page 183. The conditions of run N are stated on page 179 as follows:

"413 N HCl acid was passed directly from the stoneware crock at 1 gallon per minute at 85° F. through the tubing system."

This run is referred to in PX-184 as run 2-C, is it not? A. 2-C is correct. That was reported as 2-C.

The Court: That goes direct, is what I was getting at. A. It goes directly into the tubing.

The Court: It didn't go in the tank at all? A. That is right.

Mr. Owen: It ran from the crock and went directly from the crock.

Dr. Carl F. Prutton

The Court: That doesn't apply to the reason why some earlier ones were discarded, because they didn't stay in the tank? A. No, it wasn't in the tank at all.

Mr. Lyon: The next is a write up commencing on page 184 entitled "Determination of Iron," and this continues through page 188, and I am going to pass it for the time being, but it has to do with the new method for analyzing iron. A. That is right.

The Court: That one of May 11, 1940, L, I should mark it reported; is that right?

Mr. Lyon: Yes. May 11, 1940, Run L, is Run 1-N in Exhibit 185.

Q. Now then we come to page 189, to what is entitled "Chemical Analysis of Run M" and No. 3, Item 3 is entitled "Copper Analyses, Carbamate method." A. That is right.

Q. That is the method that you say you adopted and actually used in your report? A. That is right.

Q. Now, there is quite a table of these copper analyses, and I notice a note on the side, "Discarded See page 256." Have you any knowledge of that? A. I will have to look at it.

Q. You have turned over to page 256. That has a table entitled "Re-Check of copper analysis, Runs D, J and M."

The Court: Can you tell us the occasion of making those and discarding the earlier figures? A. There is no date down here, so you couldn't tell just when they were run. We would like to check these figures.

Mr. Lyon: We were just calling attention to the fact that they had discarded certain copper determinations, and then it referred to a later page in the book, and there was a re-run of them, and the witness is going to make a statement. A. I would like to check the figures in the first table and in the second table with the figures used in the report. I just don't know what happened. (Checks figures.) The re-check, apparently, is just the same as the original determinations.

Q. Let me have the chemical analysis in run N on

Dr. Carl F. Prutton

page 190, and then on page 191 we have a table, "Chemical Analysis of acids from tanks," on page 192 we have a title "Study of facts involved in determining the rate of attack of acid on oil well tubing," and at page 193 we have a title "Time of contact versus rate of attack," page 194, "Time of contact versus rate of attack," on page 195 "Effect of ratio of and to area of sample of steel," page 196 "Effect of various atmospheric conditions of test," page 197 "Length of oil well tubing versus rate of attack," page 198 a table, "Effect of re-use of tubing," continued on page 199; page 200, "A comparison of freshly compared synthetic inhibited and with acid after storage"; page 201 "Effect of time and conditions of storage on rate of attack." In all I am reading you now there is no mention of time in your report Exhibits 184 and 185. A. Well, that is the reason, as I told you before, we wanted to get a laboratory test that would give us comparable figures for that large scale test and so we studied some of these factors that were different in the large scale tests from the small scale in order to get such a test, and we found for example that if you took a one inch collar of tube you got a substantial result, but when you took a three inch collar it went up for the last six inches in length, which was about as large as we figured we could go.

The time of contact had an effect on the percentage of inhibition, and one of the major factors, however, was this cutting of a small piece of steel, cutting and getting so much of an edge, that metal that has been worked very strenuously is different, and the final results are that test that we described, all this work, and to put in all those details, we didn't feel it was worth while. We tried to verify these reports to bring out the major factors involved.

Mr. Owen: Well, I will state in that connection, Your Honor, that these reports were not prepared with the idea they were going to be offered in evidence.

The Court: I understand. They are documents we are prying into for the purpose I indicated.

Mr. Lyon: Before we commence with the next run

Dr. Carl F. Prutton

entered in DX-190, I want to stop and ask you about a comparison that I note between this run I, which you did not report, with run H, which you reported under the number 2-M, and run A, which you did not report. I note that this run I, which I am interested in, that the conditions as stated at page 105 show that that was a synthetic acid, an acid made up of adding the copper and lead, and that you added about 4 parts per million of copper and 225 parts per million of lead. A. Does it state that I added 4 parts per million of copper?

Q. That is the figure that we get out of here, if it is any— A. (Interrupting): Does it state that?

Q. It says 15 per cent HCl acid, containing 2 PbCl₂, and CuCl₂, so the composition of acid is similar to that in run H, and run H gave about 4 parts of copper and 225 of lead? A. Similar is not identical.

Q. Now, then, in that test you would have a synthetic Menaul tank acid, run down the pipe, isn't that correct? A. We would have a synthetic acid of whatever concentration we had there.

Q. And run down the pipe. There would be no tank with the lead plate in it? A. No.

Q. And the connection to the pipe? A. No.

Q. Whereas in run H, which became 2-M, you did have the tank and the battery to produce the tank acid, and you ran that acid down the tank with the connection, with the so-called tank connected pipe—isn't that so? A. I believe so.

Q. Now, as reported here in this run I, which had no connection between the pipe and the tank with a battery in it, you found that in the—that during the progress of the acid down the pipe, the acid removed 670 grams of iron; whereas, in the comparable test H, which you reported as 2-N, where there was a connection between the tank with the battery, or the lead plate as the battery, and the pipe, the loss of iron, or the removal of iron in the pipe was 265 grams? A. That number 670 you have on a slip of paper there—you did not get that out of the report?

Dr. Carl F. Prutton

Q. Well, I have it here in a calculation that we have made. A. Oh, but I am very certain it is wrong, that calculation.

Q. Will you tell me, according to the results as you have them reported here, and calculate it, if necessary, the amount of iron in grams that were removed from the pipe, in the passage of the acid down the pipe in run I, which you did not report? A. I told you that I would have to have the book for some little time to make that calculation, and you wouldn't give me the book over noon.

Q. I am going to ask you to make that calculation, because if that is the correct amount of iron that was removed in run I, or approximately the amount, as compared with the amount of 265 grams, which is reported in Exhibit PX-185 as 265, the result obtained in run I in that respect is entirely contrary to the conclusion that you drew and reported in Exhibit PX-185? A. This morning I went into quite a lengthy explanation of why we discarded run I. And the run did not duplicate this other run. And the acid as prepared ready to run into the tubing had a very low inhibition measured in laboratory test and the acid run in the other run had a higher inhibition, almost twice as great.

Q. Now, why did you say you discarded run I? A. Because the effluent acid from run I was extremely low in copper, and we have definite reasons for believing that some mistake was made in the copper addition in that particular run.

Q. We are not interested in the copper addition. We are interested in the comparison of the amount of iron that was removed in the passage of the acid down the pipe. A. Wait. You have got to compare that when you are talking about iron removal, because there is a tie in between copper and inhibition.

Q. How much copper did you determine to be in the acid as you prepared it in the crock? A. I explained to you that we ran the sample and, as I recall it, the parts per million came out to be 4.

Q. Yes. A. That is about as I recall what we were

Dr. Carl F. Prutton

aiming at. Then the sample of the effluent acid came out to be about 1.3 or 1, and then the inhibition tests of the original acid showed about 16 per cent inhibition on this small scale test, whereas the synthetic acid that contained three or four parts per million of copper all ran 30 or 40 per cent inhibition, so—that is, on the small scale tests, and therefore we knew that something was wrong.

Now, it seems when we got all the figures together, we had no more of this original sample of acid and we couldn't go back and run the copper, but there was three things completely wrong with the sample, and this figure that we got, and the figure that we will give you is 471 grams of iron dissolved in that run, which is the corrected figure, still shows 50 per cent inhibition, and that is what one would expect if you had about one and a half parts per million of copper there.

In other words, the iron loss agreed with the concentration we found in the effluent acid and with the per cent of inhibition that we found in our laboratory test on the original acid, indicating that there was something wrong with that acid.

The Court: Let me see if I understand your statement. I got this notion, that acid in H was made by the lead plate in the system that you thought was comparable to the transportation tank. Is that right? A. That is correct.

The Court: I thought that H, after you had treated it in the way you thought was comparable to the transportation tank, that you did analyze it and find out what it contained. A. Yes.

The Court: The thing you prepared was I, synthetically, as you thought, to put in those same ingredients that by analysis you had found in H. A. That is correct. We thought we had put them in.

The Court: Well, now, wouldn't the natural conclusion of that be, of two treated in that way, that you would be more positive about what was in I than you would in H? What I was thinking was that the only way I can be wrong

Dr. Carl F. Prutton

—not the ego I, but the letter I—could be wrong would be by an actual mistake in making the synthetic? A. Yes.

The Court: While in H there is the opportunity always present in an analysis of not getting everything into it just right. I think of the two, in other words, if I was making up a batch of water and salt and sugar, and I took so much water and so much sugar and so much salt and put them into the thing, I would be more sure about what was in there than I would if somebody handed me some water and salt and sugar which they had mixed up and I went into the laboratory and analyzed it. Maybe my logic is poor there. A. Well, it is difficult to tell the different degrees of reasonableness, except that there are three or four factors here which enter into indicating that a mistake in weighing of the copper, or some factor like that actually occurred.

Q. (By Mr. Lyon): The copper was actually weighed out that was put into that in I? A. Yes.

Q. And you did analyze the acid after you made it up? A. Yes.

Q. And determined actually by that analysis that there was the four parts per million of copper present, did you not? Did you get my question, Doctor? A. I did not. I was looking for something here.

Q. I say after weighing out the amount of acid in accordance with what you found you needed, I mean after weighing out the amount of copper in accordance with what you determined would be necessary to add to correspond to the acid produced in run H, you did actually add that copper to the acid, and then after the addition and the acid was made up, you analyzed the acid and found by the analysis that there were 4 parts per million of copper present in the acid, as shown by your records, isn't that true? A. I have to refer to these records that I have to see exactly what was done, and after I do that I will answer the question. The runs that we are comparing are H and I. H is 2-N. April 13, 1940. In 2-N the parts per million of copper is 2.88, and the amount of copper that actually was added to the acid in run I is about 2.4 parts per million of copper.

Dr. Carl F. Prutton

The Court: Now what was H? A. H is 2.88 parts per million found by analysis. Added 2.4 and it was about two-tenths of a part per million of copper in most of these acids. I don't recall the exact number for that batch of acid, but that brought it up fairly close to the 2.88. Now, that is what was recorded in the book as having been made. The figure that was found by analysis was 4 parts per million in that acid, which on the face of it definitely indicates some mistake was made in the analysis.

The Court: How about this for the mistake, that there was something in H on your analysis you hadn't found that does this extra trick, how about that for a reasonable conclusion? A. That in H that there was something else?

The Court: There was some ingredient that you haven't yet found and don't know anything about that does this trick of the difference? A. I don't believe that that is the case.

The Court: What is there to disprove that? Wouldn't that be—if you didn't make any mistake in either one that would be a logical conclusion, wouldn't it? A. If there is absolutely no mistake made.

The Court: Yes. Then your conclusion would be that there was something in that H that you hadn't analyzed for, hadn't found. I don't know, maybe something, X, Y, Z. A. I believe that would be fairly logical, yes.

The Court: I don't know whether that is a logical conclusion or not. A. But it is one of the things that you have got to consider. First, the fact that 4 parts per million were found, and there was only 2.6 parts per million which was in there, if the man had weighed out the chemicals correctly, indicating that he made some mistake in that analysis.

The Court: I don't believe I have got that line of reasoning, Doctor. Give it to me again. A. The amount of copper chloride that was weighed out corresponds to an amount that would increase the copper content by 2.4 parts per million.

The Court: In other words, if you made no mistake

Dr. Carl F. Prutton

now you had the same amount of copper in both of these?

A. About 2.6 compared to 2.88, or something like that, very close, if there was no mistake.

The Court: As I understand, you were making them as near alike as you could? A. Yes. And in the analysis the one sample I that was analyzed showed 4 parts per million. That was taken at the inlet of the tank in the run. That is out of the crock. This is a crock run in I. That sample showed 4 parts per million of copper, which is evidently higher than it could possibly have been unless some sort of a mistake was made some place. Then the analysis of the effluent acid leaving the piping system showed about $1\frac{1}{2}$ parts per million, the copper solution leaving the pipe—about 4 samples of that were analyzed, and they all showed about $1\frac{1}{2}$ parts per million of copper.

The Court: How long after you put this copper into that before you analyzed it and got the 4 parts per million? A. I don't recall the time.

The Court: I mean the one you made synthetically and you had it in what at the time? A. In a stone crock.

The Court: And you put in your copper, and then you analyzed it. You put in what would take it up to 2.88, and then analyzed it and had 4. A. Yes, that was what the analysis showed.

The Court: Now, how long intervened? A. Not a great deal of time. It was probably the same day, the same day the materials were put into the tank. And that is the figure that we question and we cannot check because we ran the inhibition of that sample and it showed an inhibition that would correspond to about $1\frac{1}{2}$ parts per million of copper.

The Court: One and one-half? A. Yes.

The Court: Not four. A. No.

The Court: Nor not the 2.88. A. No. Something went wrong I cannot explain.

The Court: You think you made two mistakes, then? A. Everything except the four, yes. Two mistakes. I think that is possible.

Dr. Carl F. Prutton

The Court: You think out of the four two of them must have been wrong? A. No.

The Court: Well, now, there were only three places for mistakes, as I understand. One putting in this 2.88, or what would bring it up, the other analyzing it and finding the 4, and the other is the amount of iron that it ate. Two of those must be wrong. A. Two of those three, but there is this inhibition of the original acid which checked the $1\frac{1}{2}$ parts per million of copper. We ran the inhibition of that original acid in the laboratory test, and that agreed with—

The Court: That analysis— A. That is, the acid that we took out of the crock. It attacked the steel in the laboratory test and it did not show as great an amount of inhibition as it should have if it had the 2.88 parts per million of copper in it. You see, we ran not only the analysis of the inlet acid but ran the inhibition of the laboratory acid.

The Court: Now, did you run an analysis of the commercial acid you bought? A. Yes.

The Court: Then you got four. How are you going to help those two mistakes? One is either you were wrong in analyzing the commercial acid or you were wrong in the amount of copper you put into the commercial acid, or you were wrong in the analysis after the 2.88 had been added together in that analysis, or you were wrong in your weights when you figured out that it had had a loss of 640 grams in the pipe. Now, is there any other place where there might have been an error? A. Well, let's go through them again. First, the analysis of the raw acid. The second is the weighing out of the copper.

The Court: That you put in with it to bring it up to 2.88. (Witness continuing): The third is the analysis of the inlet solution for copper.

The Court: Which means the solution after you had put the two together, put the copper in. A. Yes, sir.

The Court: The fourth is the testing of the inlet solution for inhibition in the laboratory test to test how effectively it was inhibited in the laboratory tests, a check on

its composition. That is what I referred to, as being on the tubing. A. Oh, no, that was just a little sample.

The Court: That is a laboratory test. Then we have the increase in iron content in acid running through the tube. All right. Now, then, the fifth? A. That was the fifth. Then we have the loss in weight in the tubing, sixth.

The Court: Sixth? Then the fifth I did not get. I thought that was the loss in weight. A. That is figured from the increase in iron content from our solution; that is, we determine the iron accurately by finding out how much iron was dissolved by the acid.

The Court: In solution? A. In passing through.

The Court: That is, how much of it was lost, in weight? A. How much the loss in weight was.

The Court: Now, you have got six. How many of the six must be wrong? A. I think probably two.

The Court: Two of the six? A. Yes, sir.

The Court: Have you any choice as between where they are most likely to make a mistake? A. The most likely—it is difficult to say, but it seems as though the weighing out of the copper would be the one least likely probable, and yet I think that is the one that probably is the thing that is wrong.

The Court: It seems like the least likely one? A. It seems like the least likely one to make.

The Court: Now, you have got to make another one. What is that other one? A. The analysis of the inlet acid, and the weighing out of the copper.

The Court: That is the other step that is one of the two? A. Yes.

The Court: Why have you reached that conclusion? You have picked for your first choice the one that you would be least likely to make? A. Yes.

The Court: Why have you done that? A. Because all four factors, other than those two, point definitely in the same direction. First, the effluent acid shows $1\frac{1}{2}$ parts per million of copper. The inhibition that we determined on the laboratory test on the inlet acid gave an inhibition

Dr. Carl F. Prutton

corresponding to $1\frac{1}{2}$ parts per million of copper. The loss in weight of iron of the tubing, the loss in weight of the iron in the acid both pointed towards that performance in the acid, which is about $1\frac{1}{2}$ parts per million of copper.

The Court: Has there been any effort made to repeat? You couldn't get the same thing, but repeat in a similar way this experiment, and see how it would come out? A. Yes; we have two repeats on it, F and J. Run J is the repeat of this particular run and is reported in the report as 2-B. Run 1-B and run 2-B both are duplicates of this type of test.

The Court: Well, 1-B is F, isn't it? A. 1-B is F.

The Court: And what is the other one? A. The other one is 2-B. Run J.

The Court: 2-B. 2-B was not reported. A. Oh, yes. 2-B was reported.

Mr. Lyon: You mean 2-B in the new series? A. 2-B in the new series.

The Court: Now, then, you have run how many checks— A. (interposing): There are two checks on it.

The Court: You have run two checks one way and one check the other, then. A. We run two checks that we reported here.

The Court: You have run three checks or two in this method? A. Three in this method, yes. 1-B, 2-B, and the one not reported, but—

The Court (interposing): You have just got a fair majority. A. No, we have eight to one, nine to one.

The Court: But that is other reports. That is other methods? A. No, by running directly from the crock we have shown that iron makes practically no difference in the tests.

The Court: As I understand you, 2-B and 1-B are identical with those? A. Crock acid.

The Court: With the one that was not reported. A. With the Menaul.

The Court: In other words, I have been figuring them here, F and J were identical with I, and I am not taking

Dr. Carl F. Prutton

your new series. I am taking the old. A. F and J are identical with I.

The Court: F and J are identical with I. A. They have the same amount of lead, about 3 parts per million of copper, and they have 1300 or more parts of iron, quite a high iron content such as we got out of our Menaul tank, but we have two other runs that are in here, in which we prepared synthetic acids duplicating the analyses that Dr. Bartell turned over to us from the defendant's field tank samples, that have about the same copper and about the same lead, but the iron is somewhat lower, so there are four running from the crock with synthetic acid. Now, even if we take this run I and throw it in, it doesn't make a great deal of difference as we see it, and I would be just as willing to do that, if we say—

The Court (interposing): There is so much difference that I was — A. (interposing): No, the difference—

The Court (interposing): Don't you think that if we ran—I am not asking that it be done—a hundred times, you get 95 of them that would run along pretty close together, probably? A. I do not think you can check extremely closely. We have quite a bit of evidence on this I that something went wrong, and the weight loss is not the figure that Mr. Lyon gave to you. He gave you a figure he figured out erroneously, and not the figure we have given. The figure we have is 471 grams of iron lost, which is over 50 per cent inhibition in this run I, over 50 per cent inhibition in run I.

The Court: Which one of you are right? One of you is wrong. A. That is what I am supposed to provide proof to Mr. Lyon on when I can get that data book.

The Court: One of you simply make a mistake. A. So I wouldn't object to throwing that in as another run.

The Court: I am not looking for an average. I am looking for the right. A. - Yes. I did not feel that that was a run that would cause me to question seriously that something radically was wrong with our tests; that something happened on that particular run; Just what it was I can't explain.

Dr. Carl F. Prutton

The Court: As I now understand it, you have three others that you think are comparable with this method? A. We have four others.

The Court: F and J and what are the others? A. We have 2-D.

Mr. Owen: What is the original number? A. Run N and run Q.

The Court: O, P, Q. All right. Q you think is comparable with this? A. Yes.

The Court: And what other ones? Now, I have got as comparable F, J, Q and M. A. And I also feel that the runs using the Menaul tank where no wire was connected are also comparable, where there was no electrical contact that could possibly be exerted, and the composition of the acids run through there are comparable. The stoneware crock did not exert an effect and the tank when it was electrically disconnected could not exert any effect. So I would say there are at least six tests that are comparable with this run I, and run I, there are two-thirds of the facts which indicate something wrong, and even if you throw the thing in and say, well, assume that you weighed it out right—

The Court (interposing): That part doesn't interest me. I was interested in seeing whether it was in error, and I agree with you that I can't make it now, with the light I have, I can't explain it on any theory except that there has been a mistake somewhere? A. That was our belief, and that is why we did not include it.

Mr. Lyon: Even under your figures where the amount of iron eaten off the pipe in run I, to-wit,—what is the figure as you gave it? A. 471 grams.

Q. As compared with 265 grams in run H, run I is contrary to the conclusions that you reported in your reports, PX-184 and 185? A. It is somewhat off, I will admit that frankly.

Q. And the results of run I in that comparison would be favorable to the defendant in this case? If it was an error, it was an error in the defendant's favor, and not in the plaintiff's favor, that is true, isn't it? A. If we

Dr. Carl F. Prutton

had not found these four or five facts that indicated that an error had been made, then I would have seriously questioned all of the work that we had done.

Q. But that isn't the question I asked you, Doctor?

A. Will you repeat the question?

Q. I asked you if there was an error, it was an error in the defendant's favor, and not the plaintiff's? A. That would be correct.

Q. Which has been true of each and everything that you have excluded on your own explanations today. Every time you made an exclusion that we have discussed, the error, or the point which you objected to, was always in the defendant's favor, isn't that true? A. I don't believe that is true.

Q. Mention one of the things that you excluded because it was in the plaintiff's favor. A. I can't recall all the things we discussed, but the reason for doing these things was to present a simple and concise picture of this in a practical manner, of these inhibiting effects of these metals, and not cluttering up of any report or dragging in millions of numbers to becloud the picture, is the thing that I did not want to do there. I have freely testified when asked for information about any of these tests, as to what our motives and what results we got, and so forth, and I have not hidden any errors that we made.

Q. You haven't answered the question yet. You have argued about it. A. I don't believe that all of the things we have dropped were favorable to the defendant.

Q. Can you name one that was favorable to the plaintiff? A. I don't recall.

Q. Well, now, let us go on. Commencing at page 218 we have the next run, which was run O, dated May 1, 1921. This covers pages 218 to 221 of Exhibit DX-190. It says, as to equipment, the same as had been used in run K. The tubing had been previously used in runs D, H, I, J, K, M and N. That means the same tubing that you—that you used the same tubing in all those runs, is that correct? A. Yes, that is correct.

Dr. Carl F. Prutton

Q. The conditions of the test are stated as follows: (Reading): "The tubing system was filled with crude oil. The oil was then drained, and the system sealed. Approximately 24 hours later the seals were broken, and the oil that had collected in the bottom section was removed. The run was started. The 15 per cent hydrochloric acid was passed directly through the tubing system from the stoneware crock at one gallon per minute at 85 degrees F."

I think that I brought out on cross examination that you had made this run, but you did not mention it in Exhibits PX-184 and 185? A. I believe it was brought out on direct examination.

Q. But it was not mentioned in your reports that are offered here in evidence? A. No, because the reports did not touch on oil.

Q. Well, now, I think you stated, or gave a figure based on this test as to the extent to which the oil tended to reduce the rate of corrosion. Now, what was that figure, Dr. Prutton? A. As I recall it, it was around 60 per cent, or 70, somewhere in there.

Q. How many? A. 60 per cent.

Q. Then it is probable, is it not, that if the acid were being fed through the pipe at a very different rate of speed, say six or seven or ten times as fast as you were feeding the acid through there, that the oil would have affected the amount of corrosion in some other figure, is that right? A. Well, the rate of speed would have something to do with the attack, and the amount of wiping off of the oil from the surface; but the inclination of the pipe would have a considerable bearing on just how it would wipe it off.

Q. Did you make any tests with the pipe upright? A. No, we did not.

Q. To determine what the effect of oil on the pipe would be? A. We made tests, in our laboratory tests, which was the—the tubing was practically in a vertical condition. It was the same pipe sections in the laboratory tests.

Q. Did you flow the acid through a vertical pipe that

Dr. Carl F. Prutton

had been oiled? A. No, I say we did not do that. We could not do it.

Q. Did you make any other tests except at this rate of one gallon per minute, I mean, where you had it at say, the rate of 750 gallons an hour, to see what the effect of the oil would be? A. No, we did not.

Q. Now, the next run in this book begins at page 222, and is run P, dated May 11, 1941, and the equipment is stated as follows, the same as had been used in run K; the tubing had been previously used in runs D, H, I, J, K, M and N and O. That is correct, is it not? A. I believe so, if you are reading from the book.

Q. The conditions of the test are stated on page 223.

(Reading): "Before removing, each section of tubing was filled with crude oil and allowed to drain for at least twenty minutes, and then the section was assembled and the run started. Half of the acid was passed through the system very rapidly, and the remaining was passed at one gallon per minute, at 85 degrees F."

Did you get any values to show what difference it made in the rate of corrosion when the acid was being passed through the tubing quickly, as compared with a flow at one gallon per minute? A. Well, at this rapid rate. I don't recall the rapid rate. Do you recall that, Mr. Lightfoot?

Mr. Lightfoot: No, I do not.

(Witness continuing): It is in the book?

Mr. Lyon: I can't find it.

(Witness continuing): It was a very preliminary run and I don't know the rate that was used.

Q. I notice at the end of this under Mr. Lightfoot's signature, with his initials (I don't know whether he wrote it or not) page 225, the following note: "Comparison to other test invalid because of ratio of acid flow used in this test." Did you write that, Mr. Lightfoot?

Mr. Lightfoot: Yes, I did.

Q. Well, I take it from that, that comparisons of these tests are not valid, the results of these tests are not valid, where you have a marked difference in the rate of

Dr. Carl F. Prutton

acid flow, is that correct? A. They are sort of mixed up. The test, some of the acids run through fast, some slow, and it was sort of seeing whether we could get any figures out of this equipment at all.

Q. I take it from that note you arrived at the conclusion if there was a change in the rate of flow of the acid, that you could not then validly compare the results of the tests, is that correct? A. I think that comment was largely dictated by the fact that we feel that these tests we couldn't compare a test running acid through at 5 gallons per minute through the same tube as we could with one going one gallon per minute. That test was run with this mixed up rate of flow and therefore we didn't feel you could compare these figures with any of our one-gallon per minute runs.

The Court: Would the corrosion be greater when it ran rapidly? A. I don't know that that would be true. It should be greater. The amount of iron should be greater.

The Court: I say that that is the reason. What other reason? A. That is all, and the peculiar flow conditions of this oil that is in there.

The Court: Wasn't it all comparable except the speed? A. The speed and the inclination of the pipe which permits the oil to run up on the top surface of the pipe, whereas in a vertical pipe you have a different—

The Court (interrupting): All three of these were in the same position, weren't they? A. They were in this horizontal, practically, pipe.

The Court: As I understood it, I understood the three tests were all just exactly alike except the one you discarded had a different speed in it than the other. A. No, these are not the same kind of tests we ran before. These are the ones we ran the oil in.

The Court: How many oils? A. Only two oils.

The Court: How many did you save? A. Didn't save any. We reported the general results here in direct testimony but we didn't prepare a table of them because we didn't feel in almost a horizontal tube you get the same—

Dr. Carl F. Prutton

The Court (interrupting): But you treated all of those exactly alike. A. Exactly alike. It showed a reduction in iron.

The Court: As I understand there are figures that show the results, why you didn't report it, but do I understand in this book he is looking at there are figures about all of them? A. About the two runs.

The Court: And then there is one that you haven't got the figures for? A. No.

The Court: How many runs are shown there? A. Just two oil runs and all the data is there. I gave on direct testimony the general results of that test.

The Court: But I am talking about the figures in that book. There are figures there for both of them? A. Complete.

The Court: You haven't treated one any differently than the other? A. I just made a general statement. We didn't figure out the results of the test.

Mr. Lyon: There is a note at the bottom of the second run P "Comparison to other tests invalid because of the ratio of acid flow used in this test."

The Court: Now, does that apply to both of them? A. No, only to one.

The Court: Now, the only difference there and the reason you think that cannot be used is because of this difference in the flow, that part of the time it went faster than the other? A. No, that is not the entire story.

The Court: What is there in there that that should be discarded any more than the other? A. I don't think any of them should be discarded.

The Court: But you made the note. A. Making the note implies a comparison of a run in which we use 5' per second flow. Every other one was run at 5' per second.

The Court (interposing): Now, the conclusion I get as to why that one is less valuable than the other, do you think that one is less valuable than the other? A. I think neither one of them have any great significance, and that is what I testified.

Dr. Carl F. Prutton

The Court: Well, if there is any difference in value as between one and the other that I can see, it is because one ran at two different speeds and the idea is that a different speed makes a difference in the amount of corrosion.

A. Yes.

The Court: That is the only explanation I get. A. Yes.

The Court: And this difference is that the faster it runs the more it eats. A. That is right.

Mr. Lyon: Now, just on that point, when you say the faster it runs the more it corrodes or eats the iron, you don't mean to say that if you are measuring the amount of iron in a gallon of the acid after it had gone through the pipe you would find a higher percentage? A. No. We discussed that.

The Court: I am talking about a measure of time. I am saying in an hour, as I understand, if the acid runs by at a rapid rate it eats more in an hour. A. Yes.

The Court: Than it does if it runs by at a slow rate, but I did not get the idea that if it ran by rapidly the gallon, one gallon, would eat more. In fact, if I was going to guess about it I would guess it would eat less. A. That is exactly what it shows.

The Court: Because it would have less time, that particular gallon, would have less time for its lunch.

Mr. Lyon: Did you make comparable tests of that kind and record them in this book, PX-190? A. There are some figures of iron content of the acid leaving the system, and I think it shows that, in this first part of the run, where it ran through fast, there was, oh, .2 milligrams of iron per cubic centimeter, and when it slowed up to one foot per second, why, there was .4, showing that the concentration of iron in the acid was lower, but I am quite sure that the total amount of iron dissolved was greater. We did not calculate that or measure it. We couldn't tell.

Q. That is what I want to know. You say you are sure about that. I haven't found any test of that kind in this book, if there is one. A. Here is the reasoning—

Dr. Carl F. Prutton

Q. (interposing): I am not asking about the reasoning. Have you actually got any tests in this book showing the total amount of corrosion in a given length of pipe if you pass different amounts of acid through it in the same length of time? A. No, I don't think we have the data. Mr. Lightfoot, do you know the rate we ran that through? Was that five gallons a minute or something like that?

Mr. Lightfoot: No, the first part of this run—

Q. (interposing): You don't know how fast that was, exactly?

Mr. Lightfoot: As fast as we could handle it conveniently. A. You don't know how fast that was? It was more than two gallons?

Mr. Lightfoot: Yes.

A. More than two gallons a minute. Just from his visual observation, it was more than two gallons a minute for the acid going through the pipe. The acid through at one foot a second picked up .4 milligrams per gallon and going through at that fast rate, faster than two gallons a minute, it picked up .2. It would be quite a good rate.

Q. Do you find those figures here? A. I say it isn't in the book and I can't prove it. As I explained before, those runs were simply runs made to see what would happen and see what kind of flow conditions would be obtained.

The Court: Can you tell me, Doctor, we have got two things to conjure with, that is the amount of acid passing over the iron, and we have got the length of time? Now, I understand that everybody is agreed, if not, I wish everybody would stop me in my thought, I understand that you are agreed that the longer the time to which a surface of iron is exposed, the greater the amount of corrosion? A. Yes.

The Court: And it is practically directly proportionate? A. Approximately.

The Court: Ignoring the speed is uniform now? A. Yes.

The Court: That is, it is pretty near in proportion to

Dr. Carl F. Prutton

the length of time, directly in proportion. Now, I do understand that you are also pretty well agreed that iron exposed for the same length of time at a speed of one gallon per hour, the corrosion is less than it would be if it was exposed twenty gallons per hour? A. That would be my contention, but—

The Court: I understand you. A. That is my belief.

The Court: I understand you and Mr. Bartell to say that? A. Yes.

The Court: Is there any question about it, or is that something discovered since, or is it well known? A. I think that is well known by practically every one in the acid treating business.

The Court: Now, we get down to a point, and I take it nobody yet has told me, and it is not so easy to see how the relation of the amount of corrosion compares to the speed. I am satisfied that it is not in direct proportion to that. I feel no hesitancy in saying I have got the notion that because it would eat a certain amount in an hour going at the rate of one gallon an hour, and you put it up to two gallons, I am sure it wouldn't eat twice as much, but can you tell me anything about that? Is there any mathematical figure of relation or proportion? A. I can't tell you any definite relationship. I think some of the men that run these inhibitions possibly could tell you, give you some better information.

The Court: You don't know of any scientific figures to enlighten us about that? A. No, I don't.

The Court: All right. I can see that is a more debatable and a more difficult question than the other. All right.

Mr. Lyon: The next experiment is entered in the Exhibit DX-190, commencing at page 227 and is entitled "Pressure corrosion test." The data on this seems to continue over and is concluded on page 231, signed by Mr. Lightfoot. You have already told us that you found pressure didn't make much difference? A. No. It makes a little difference, but it reduces everything in the same amount somewhat.

Dr. Carl F. Prutton

Q. All right. Now, the next run or the next entry in DX-190 commences at page 232 and is entitled "Run Q, June 24, 1941." The statement as to the equipment is as follows: "Same as has been used in run M, tubing had been previously used in runs D, H, I, J, K, M and N, O, and P." There seems to be no remarks on the condition.

The Court: That pressure one is what? A. That is the oil one.

Mr. Lyon: That is the second oil one. There were two oil runs, O and P.

The Court: All right.

Mr. Lyon: Now, there don't seem to be any remarks here about the conditions in this treatment, but this treatment Q is the one which was reported as 2-E in Exhibit 184, 2-E, that is correct, is it not? A. Yes. On page 237 the conditions of this test are stated.

Q. I was in error in my previous statement when I said there were no conditions given for this test. The conditions are on page 237 of the exhibit, and they read:

(Reading): "4.465 NHCl acid treated with FeCl_2 , 4 H_2O and PbCl_2 and CuCl_2 , to be passed from the stoneware crock at one gallon per minute and 85 degrees F. through the tubing system." A. That is correct.

Q. I notice something that may have some significance here, in reporting how the copper was added in some of these other tests, copper chloride is indicated, whereas here the formula Cu_2Cl_2 , which is cuprous chloride— A. There is cuprous chloride and cupric chloride. As I recall in some runs we used cupric, and then towards the end we used cuprous.

Q. Does that make any difference? A. The effect is immaterial in that the amount of metallic copper that is in there—the only thing that could happen would be that this cuprous—the cupric chloride would react with the iron pipe and would be reduced.

The Court: And you put that in by weight? A. By weight, yes, and you then figure the copper content.

The Court: I see. A. The reason we changed over

from one chloride to the other, and it would have absolutely no effect whether it is cuprous or cupric, the reason we changed over was that the cupric chloride, as you purchase it it is labelled $2\text{H}_2\text{O}$ —it is in the form of crystals, in bottles, and seems to be partially dehydrated, and we did not feel that we could count that as well as the cuprous chloride, which is anhydrous.

The Court: But you take, say, a pound of cuprous chloride, just the same as you take a pound of the other? A. Yes. We chose the cuprous chloride because that comes in an anhydrous form, and the cupric came in a dehydrated form, and the crystals of it seemed to be partially dry, which would indicate it was not quite the pure hydrate, so we thought it would be more advisable to use the cuprous. There is no possible change that it can make in the test.

Q. In the title data on page 237 there is the following notation:

(Reading): "To 192 gallons of 4.465 NHCl , 420 grams of PbCl_2 , 3.97 grams of Cu_2Cl_2 were added."

The Court: And that is what? A. Cuprous chloride.

Q. The second has twice as much copper in each molecule as the first? A. I don't think it is twice as much—I mean, atomically it is, but by weight—in other words, there are two atoms of chlorine to one atom of copper, and one atom of copper to two atoms of chlorine in cupric.

Q. Well, what I mean is there are twice as many atoms of copper in the second as the first? A. Oh, yes.

Q. This run Q was reported as run 2-E. We may already have covered that, but I say that to make it clear. A. Yes.

Q. Following the write up of run Q, commencing at page 240, we find various data recorded commencing with a title "Laboratory Tests on the Inhibiting Properties of Crude Oil on Oil Well Tubing in 15 Per Cent Hydrochloric Acid." And with notations on that subject. And then on page 245 we find the title "Study of rate of attack of hydrochloric acid on oil well tubing, small scale model, laboratory set up," with the title, "Sketch of Apparatus Used."

Dr. Carl F. Prutton

This apparatus shows two containers, each containing acid, and in each container a sample of tubing, one container sample of tubing is numbered A and the other is numbered B. And the tubings contain connection—are connected by a connecting wire outside of the two containers and extending across from one sample to the other, outside the acid, and then also connecting the two acids and extending to the two containers is a capillary glass tube, and then also connecting to the connecting wire previously mentioned, and the connection being outside the acid, but extending into the acid, is a lead sheet.

Now, will you tell me what you were trying to prove by that apparatus and whether you got any results out of it that proved anything? I see nothing about them in your reports. A. No. I told my assistant, Mr. Lightfoot, to see if we could fix up a demonstration that might be brought into court to demonstrate the fallacy of this Menaul process, and the difficulties experimentally that we encountered in getting the capillary full of acid, and so forth, and it just didn't work out very well, and we didn't even get protection over here of the oil well tubing with the lead, so it looked—the results would all indicate that it didn't protect any place. The things were so—it just didn't work. It was—

Q. (interposing): These tests or these recorded values that follow this, through to the title "Run Q Inhibitors" on page 252 were all the results of experiments on that attempted set up? A. Run Q?

Q. Up to where there is a title "Run Q Inhibitors—Inhibition." A. Oh, yes.

Q. If those are what they are about, I don't care to stop on them. A. No, there are some other things in between here.

Q. How far does that data go? A. It goes from here to here. There is 1, 2, 3 sides of a sheet. Is this included; is that part of it?

Mr. Lightfoot: Yes.

A. No, that is another thing, steel strip.

Dr. Carl F. Prutton

Mr. Lightfoot: Yes.

A. About two and a half sides of a sheet here discuss those crude attempts at trying to fix up a demonstration model to show that this thing wouldn't work.

Q. That is the end of page 247? A. Yes.

Q. All right. Then on page 248 we have a title "Demonstration Inhibition Test using Steel Strip alone and each steel strip coupled to a lead strip being bolted together above the surface of the acid and spaced about one inch apart in the acid." You remember that? A. Yes, that test was run, but I don't know how important it was considered, but when the Menaul patent was obtained they went into the Patent Office and had a lot of discussion with the Examiner, and the Examiner claimed that it wouldn't work, and then they proved that the potential is in the right direction, that it would work, and he still claimed it would not work, as I recall, so they got Dr. Gardner some place to run tests connecting the lead strip to a piece of steel and he showed you got 90, over 90 per cent inhibition.

Well, on the basis of that, they were awarded a patent. I think that was the determining point, because very shortly thereafter they were given a patent. And we were just checking up to see. We couldn't get hardly any inhibition at all. We got 20 or 30 per cent. If we had left the lead sheet in there for a length of time, for it to dissolve, maybe we could have got 90 per cent, but we did not check Dr. Gardiner's work.

Q. All right. Now, then, the next page, on page 249, it is entitled "Special inhibition tests using steel strips submitted by the Dow Company." What is that about?

A. That was in connection with the pressure test work. I think we ran them outside the pressure bond and then inside the pressure bond, is that correct?

Mr. Lightfoot: Yes, that is right.

A. And I think these are outside. Are these outside?

Mr. Lightfoot: Those are outside.

A. At atmospheric pressure, and we used the same strips like the Dow Company used in their inhibition test.

Dr. Carl F. Prutton

Mr. Lyon: And then the next thing, on page 250, is a title, "Check on acid run O,"—I can't read that next word. A. Preliminary. In other words, that was a preliminary run.

Q. What was that about? A. That was one of those oil runs, wasn't it? Run O.

Q. Run O was one of the oil runs, but what was this check about? A. I don't know.

Mr. Lightfoot: That is the case where they checked the carboys for inhibition.

Mr. Lyon: And what did you find? Did you convert this to any per cent? A. After the run or before?

Mr. Lightfoot: Before the run.

Q. What did you find? Can you explain these results as to any per cent of inhibition, or reduction in corrosion? Mr. Lightfoot: That would have to be calculated.

Q. Was it calculated? Mr. Lightfoot: Well, it was calculated at the time. However, it is not entered in the book.

Q. Do you know what the results were, or have you got them at hand? Mr. Lightfoot: I can get them.

Q. All right. Either calculate them or find them. The next page is page 251, entitled "Inhibition of acid samples from old runs E, G, K, D, N, using crock composite and over-all end composite samples. Time, 3 hours, and 30 degrees C." Are these some more of those same laboratory charts with samples of metal and getting percentages of corrosion reduction that you have explained before? Mr. Lightfoot: Those are the large samples.

Q. The large samples. A. These are the end of the inlet acid of runs E, G, J, K, and M. Those are the blanks.

Q. These are the blanks again? A. They are laboratory tests that were run upon the inlet acid in the runs listed here.

Q. Were the results here incorporated or employed in the reports, Exhibits 184 and 185?

The Court: When you refer to blanks do you refer here to chemically pure acid or commercial acid? A. Commercial acids.

Dr. Carl F. Prutton

The Court: I think Dr. Bartell referred to chemically pure acid, and he referred to blanks. Here we are referring to blanks as commercial acid.

Q. That is correct, is it not? A. These are the commercial blank acids used in these particular runs, or the commercial acid diluted.

The Court: Just so we keep it straight. A. And the figures are not specifically listed in those reports, are they?

Mr. Lightfoot: I believe they are not.

A. I think in the testimony I gave some of this.

Q. As I understand, Doctor, at any time you made synthetic acid you analyzed your commercial acid and then you added to that whatever you wanted to? A. That is correct.

The Court: You never in any of your testimony or experiments dealt with chemically pure acid at all? A. We have used in our laboratory inhibition tests that I reported on, to study the effect of adding metals, we have used chemically pure acid to add metals in the laboratory tests.

The Court: Does your testimony show that? A. Yes, it clearly shows that.

The Court: All right. I am satisfied.

Q. Now, continuing the following pages up to the end of page 258, contains some similar work on inhibitions with lead and iron mixtures, and so forth. A. I don't recall what is in there.

Q. I come now to page 259, dated July 22, 1941, the day after this case started. The title is "The potentials across a lead sheet HCl and oil well tubing." What were these experiments, Doctor? A. They were checks on the Gardner affidavit that was used in obtaining the Menaul method and were to measure the difference in potential that occurred between a strip of lead and a piece of iron when put into hydrochloric acid.

Q. They were not checks across the lead sheet, hydrochloric acid, and the oil well tubing? A. Well, the piece of iron was the oil well tubing.

Dr. Carl F. Prutton

Q. Where was the lead sheet? A. Right in the same beaker with a piece of oil well tubing. In other words, we cut a strip, as I recall, out of a piece of oil well tubing, put a piece of lead into the beaker, and measured the voltage as it went across that little cell.

The Court: They were connected at one part? A. They were in a beaker like this (indicating) the top connected with a wire, the acid around it. That is the type of test Dr. Gardner reported.

Mr. Lyon: What was the purpose of this test? A. The purpose was more or less to see if we could duplicate Gardner's work. Somebody requested I do it, I think.

Q. Who requested it? A. I think Mr. Rebbeck.

The Court: Who is Gardner? A. A professor down in Oklahoma some place who made some tests and sent in a report of those in an affidavit to the Patent Office showing that this Menaul process would work. He made two tests in the laboratory.

The Court: And you were making these tests but while you were making these tests didn't that simulate according to your theory, the pipe when connected to the tank with the copper wire? A. It did not.

The Court: You say it didn't? A. Oh, no. Here we have a path of current that is direct and almost parallel; the pieces were almost together. It closely ties in with the condition they have where they have a lead plate in the bottom of the tank and a steel side, where the path is more direct.

The Court: In other words, the copper wire simply connected the two? A. That is right.

Mr. Lyon: Well, now, so we will understand your last statement, wouldn't the measurements of voltage in these tests reported here be somewhat comparable to the voltages you state you didn't measure in the Menaul tank? A. Well, if you will read those voltages, the voltage jumped quite a bit. In other words, it was variable, never very great.

Q. I am not asking that— A. Well, I can't answer in one word. I can't tell you exactly whether it is the same

Dr. Carl F. Prutton

voltage you get. I think it is in that order between the side of the tank and the lead plate, but not in regard—

Q. Mr. Lyon (interrupting): I am talking about what electrical pressure there actually is in a battery of the kind that we have in the Menaul tank. A. These figures are around a few hundredths.

Q. I am not asking you that. These figures would be comparable to the voltage or pressure in the Menaul tank? A. In between the side of the tank and the lead plate.

Q. These figures are comparable, isn't it true? A. I didn't say they were completely comparable. I said there was some general relation between them but I can't just tell you the general potential. If I may take the book and read the values. They skip all over.

Q. Well, first you determined the voltages with 4% hydrochloric acid, didn't you? A. Yes.

Q. Then next you determined the voltages with 7% hydrochloric acid, then with 10% hydrochloric acid, then with 16% hydrochloric acid, and then with 25% hydrochloric acid? A. That is right.

Q. Now, let's examine the voltages as you found them for 16% hydrochloric acid. You will remember you testified yesterday the voltage would not be as much as a tenth of a volt or $.1\frac{1}{2}$ volts. You testified to that, did you not? A. As I recall, I testified that we actually measured the potential between the tank and the tubing and it was on the order of millivolts, thousandths of a volt. The statement I made between the potential of the lead plate and the side of the tank I gave no exact figures but said it was on the order of a tenth of a volt.

Q. I thought you denied it could be on the order of a tenth of a volt. A. If I made that statement, I would correct it.

Q. All right. The figures, the voltages as you actually found them, as recorded on page 260 or Exhibit 190 for 16% hydrochloric acid, will you read them to the court? A. The figure is .18 volt.

The Court: Now, what is that? A. The voltage between a sheet of lead and a piece of steel.

Dr. Carl F. Prutton

The Court: These are all 16%? A. Yes. 18/100ths was the original voltage. As soon as it was connected it was 18/100ths. At the end of one minute it was 14/100ths. At the end of six minutes it was 15/100ths. At the end of nine minutes it was .158 volts.

Then a second run was made at 16 per cent.

The Court: You did the same thing over again? A. We did the same thing over again, with new strips. As soon as he could measure it it was two tenths of a volt. At the end of ten seconds, it was 11/100ths of a volt. At the end of one minute and ten seconds, it was 13/100ths of a volt. At the end of two minutes and ten seconds, it was 14/100ths of a volt. At the end of six minutes and ten seconds, it was 17/100ths of a volt.

The Court: This all had to do with 16 per cent hydrochloric acid? A. 16 per cent acid, yes. Now, if we go to the 10 per cent hydrochloric acid, the values are about .07 volts average. The values are—the values here were about .14, and so it is probable with 15 per cent it would be .12, or .13. The voltage changes with the acid concentration. And so the statement that it was about one-tenth of a volt—

The Court (interposing): Then it acts inversely—A. (interrupting): The higher the acid concentration, the higher the voltage.

The Court: .08 is the average for 10 per cent acid. A. And for 16 per cent acid it is about .14. And so if we would calculate for 15 it would be around .13 of a volt.

The Court: Provided you follow these others out and you find them in direct proportion to the percentage and you do find them running upward. You have only given me two. A. I will give you the rest of them. At 4 per cent—

The Court (interposing): Have you the averages? A. Just by glancing at them I can tell you about the averages.

The Court: Give it. A. Four per cent hydrochloric acid, the average was about .04 volts. And with 7 per cent acid it was about .06. With 10 per cent, I gave you that, about .08. At 20 per cent the average is about .20, so it shows some progression.

Dr. Carl F. Prutton

The Court: That is voltage you are talking about. A. That is the actual voltage between the lead and the iron.

Mr. Lyon: When they are immersed in the acid? A. When they are immersed in this particular form of cell.

Q. The direction of that potential, or the pressure, the electrical pressure will be tending to force the flow from the lead to the iron? A. From the lead to the iron.

The Court: Tell me this, now, does this prove or disprove Professor Gardner's affidavit? A. The results are somewhat different than Gardner's affidavit, but they are in the same general direction, in this part of the work.

The Court: It doesn't tend to dispute it then? A. It doesn't tend to dispute it to any great degree. It is a matter of degree and not of difference. In other words, the current, this lead was negative with respect to the iron, by a definite voltage, which should tend to electrolytically protect the iron, and his conclusion on the voltage, we agree that the voltage is in the right direction.

The Court: Then it is corroborative of his, we will say. A. In general.

The Court: All right. A. But the inhibition that we ran was completely non-corroborative.

The Court: Is the Oklahoma professor going to be here at all?

Mr. Lyon: Professor Gardner is not, Your Honor.

The Court: All right. Let me ask another question. You say it disputes, or, rather, corroborates what he says about inhibition? A. About the voltage. About voltage but not inhibition.

The Court: Well, now, maybe I either misspoke or—it corroborates, rather than anything else, the voltages? A. It agrees in general with the voltage that he reported.

The Court: But you say it is disputed as to the inhibition resulting from that? A. That is correct.

The Court: Now, did he give his—I haven't seen that,—there are so many things here, I haven't that affidavit, but does he attempt to state there some claimed experiments? A. Yes.

Dr. Carl F. Prutton

The Court: Or does he state it from scientific opinion? A. Experiments. And we tried to duplicate those as close as we could. He reports from 90 to 97 per cent inhibition.

The Court: Did he tell how he did it? A. Not exactly. He told in a general way how he did it. He told the concentrations of acid.

The Court: Did he do it the best way or the worst way? A. We just took a way of doing it.

The Court: There are different ways of performing experiments. A. We just really didn't go into it to any degree at all. Because we got that one request to check this, and then the attorneys did not keep after us, so we dropped that.

Mr. Lyon: I would like to offer in evidence at this time a certified copy of the file wrapper of the Menaul patent on the defendant's Menaul tank system, No. 2,149,617, so that I can read at this time Dr. Gardner's affidavit.

The Court: That is DX-191?

(The document above described was thereupon marked DX-191.)

Mr. Wiles: If the court please, we object to that. It is bringing in hearsay matter without any opportunity for us to cross examine. It is a self-serving declaration, where cross examination is peculiarly essential.

The Court: Not because it is proof of the thing stated, but in connection with the,—I take it all this comes out of cross examination, I take it that the witness now on the stand disputes the validity of that patent.

Mr. Wiles: Oh, no. Look, that is just the trouble with letting them go on a fishing expedition of this kind. At a certain time in this case we thought they might want to put Dr. Gardner on and prove this, and therefore we asked the witness to please make some investigations to see if Gardner is right. He gets it written down in a notebook. So far as that is concerned it hasn't anything to do with this case at all, I mean whether Gardner's affidavit to the Patent Office could be proved correct with regard to the

Dr. Carl F. Prutton

inhibition in their tank, didn't make any difference, that I know of here. Then they go and get this leave to look at our notes, and they find something that as yet isn't relevant here at all. Then they cross examine the witness and find in parts he disagrees with Gardner. Then they, having dragged out an entirely immaterial matter, they try to put in the file, and Gardner practically as a witness here, where we have no chance to cross examine him. Now, they have lugged in this stuff that hasn't anything to do with anything that the witness went into. We didn't intend to examine him about it, except possibly in rebuttal, or if they put Gardner on, or some equivalent man on the stand.

The Court: On what theory is that admissible? On what theory do you claim that is admissible?

Mr. Lyon: I claim it is admissible for two points. One, because the witness himself referred to it.

The Court: He only did on cross examination when you brought it up.

Mr. Lyon: I didn't bring it up, as a matter of fact. I think Your Honor was asking the witness some questions and it came out. A. I mentioned these tests we made were only preliminary tests.

Mr. Lyon: And he in his reports here, Exhibits 184 and 185, has mentioned this patent and disagreed with the patent and made some statements.

The Court: Those reports, are those the reports they put in evidence?

Mr. Lyon: Yes. They are the ones he put on through Exhibits 184 and 185.

The Court: I am going to go in now, if he is going—if you have attempted by direct proof to tear this patent you are talking about to pieces, why shouldn't I find out what that patent is about?

Mr. Wiles: All right: There are two things. There are two entirely different points. One of them is the Menaul inhibition of the tank, of the truck tank. The witness has said he thinks that works and adds some inhibition. We never questioned that at all, and that is what this

Dr. Carl F. Prutton

affidavit is about. Now, we say, and the witness has said that the claim of Menaul that by hitching up this little piece of iron he can inhibit down in the oil well, that that is just a plain fraud, and that isn't what this affidavit is about. The tests that the witness is now cross examined about, and that they are bringing this Gardner affidavit in, are those that relate to the inhibition within the tank. Now, we make those inhibitions in the tank and that is carried out in part by this lead plate.

The Court: Well, if I am going into that patent at all, I generally need to have the file wrapper here to know something about the patent. I will rule that that is not proof, that isn't proper proof for a defendant to bring in here, because the file and findings of the Patent Office, or somebody's affidavit, they are entitled to cross examine and know about. On the other hand, to the extent that you attack a patent, to that extent I feel I need to understand it and the theory on which it was, and all about it.

Mr. Wiles: For that limited purpose.

The Court: That is the purpose. I am not admitting the proof to dispute the document.

Mr. Lyon: I understand that. I agree with that.

The Court: I am not treating him as if he was a witness here. He is alive?

Mr. Lyon: Dr. Gardner? I never saw the man. I think he is alive.

The Court: Well, all right, I will assume that he is unless he is proven to be dead.

Mr. Lyon: I would like to read the affidavit, not as proof of the facts, but so that Your Honor may have it in mind, if you have any questions of this witness.

The Court: DX-191 is the file wrapper, and I am admitting it for an understanding of the patent, of the theory on which it was allowed, and the proper interpretation of the thing.

Mr. Lyon: The affidavit is entitled:

"In the United States Patent Office.

"In re Application of Paul L. Menaul.

Dr. Carl F. Prutton

"State of Oklahoma, County of, ss.

"F. T. Gardner, being duly sworn, deposes and says that he is a citizen of the United States, and a resident of Tulsa, State of Oklahoma; that he is Associate Professor of Chemistry at the University of Tulsa; that he has specialized in industrial chemistry and has made an intensive study of the question or problem of corrosion particularly in connection with oil field equipment.

"That his education has consisted of the following, and that he has obtained the following degrees:

"University of Oklahoma, 1 year.

"University of Illinois, 3 years, B.S.

"Cornell University, 3 years, Ph.D.

"That he has studied a copy of the application of Paul L. Menaul, Serial No. 116,786, filed December 19, 1936, for Method and Apparatus for Handling Acidic Solutions, and is familiar with the contents thereof; that he first obtained knowledge of the invention upon which a patent is sought in the aforesaid application on or about the 1st day of May, 1937, this having been called to his attention by the Ozark Chemical Company, subsequently by the Shell Petroleum Company; that both companies inquired as to whether this method and apparatus was operative, this information being desired by the Shell Petroleum Company in order to determine whether or not it was safe for them to use this method in the acidizing of their oil wells; that he made this investigation and determined that the method and apparatus were operative, and so reported to the Shell Petroleum Company.

"That officials of the Halliburton Oil Well Cementing Company, having learned of his research and experiments in connection with this invention, have requested that he study the application for patent referred to above and make this affidavit with respect to the said invention.

"That the operativeness of the invention may be clearly demonstrated by apparatus constructed as follows. The apparatus consists of strips of lead and steel immersed in a beaker of hydrochloric acid of known concentration as in Figure 1, Menaul 116,768"

Dr. Carl F. Prutton

Mr. Owen: Would Your Honor like to see that Menaul patent, and see the figure he is talking about? He is talking about Figure 1 there.

Mr. Lyon: That is right, of the patent as it finally issued.

The Court: That looks like I thought it would.

Mr. Lyon (reading): "said strips being not on closed circuit but connected by screw connectors to the wire terminals of the 'EMF' circuit of a Leeds & Northrup potentiometer having a sensitivity of .0002 volts, by means of which magnitude of voltage and direction of current flow were determined. The steel employed was a plain carbon steel of ap. 3% c. content. The lead was commercial sheet used for lining reaction chambers subject to action of dilute sulphuric acid."

The Court: What was the iron?

Mr. Lyon: The steel employed was a plain carbon steel.

Mr. Lyon (reading): "That he has conducted experiments with this apparatus at a temperature of ca. 30 degrees C. (86 degrees F.), and has obtained the following data on the voltages generated by the apparatus. In all cases the lead electrode was electronegative to the steel electrode; that is, oxidation or loss of electrons occurred at the lead electrode, while reduction or gain of electrons occurred at the steel electrode."

Then there is a table,

"%HCl by weight, and voltage."

"In all cases the lead electrode was electronegative to the steel electrode."

The Court: What do you think he means there?

Mr. Lyon: That means that the current would flow from the lead to the steel through the acid.

"3.50 per cent HCl," and the voltage was ".0455."

The Court: The voltage was what?

Mr. Lyon: At 3½ per cent hydrochloric acid, the voltage was at .0455.

Dr. Carl F. Prutton

The Court: That is comparable with what the doctor said.

Mr. Lyon: We have some more values. At 6.67 HCl the voltage was .0510.

The Court: And that is comparable.

Mr. Lyon: At 9.95 per cent HCl, the voltage was .0630.

The Court: Comparable.

Mr. Lyon: At 15.99 per cent HCl, the voltage was .0865.

The Court: We are getting off there.

The Witness: I said about a tenth of a volt, my figure was 12 or 13/100ths and is—

Mr. Lyon: It is .0865 on this table.

The Court: That is for what percentage HCl?

Mr. Lyon: That is for 15.99.

The Court: The doctor's is 14. There is quite a difference there.

Mr. Lyon: Yes, he is quite a little higher than this man, instead of lower.

The Court: Very much higher. That is the first place that they have been way apart. I would call that—maybe I am wrong in my yardstick, but I would call that, the others I look at as being—

The Witness (interrupting): That voltage is so low that two or three hundredths of a volt, Your Honor—I would say that those are practically check determinations.

The Court: Well, but there is a lot of difference where you put your decimal point. A. Oh, absolutely.

The Court: And his is a decimal and then a zero and then an eight. That is less. A. One-tenth.

The Court: And yours is over. A. Over one-tenth.

The Court: .14? A. That is true.

The Court: All right. A. But all I am saying is that voltage is small. You see, most galvanic cells, like a dry cell is 1.55 volts, and this voltage is only about one-tenth of a volt. This is practically nothing. Whether you consider one voltage or the other, we found, I would say that we agree with Dr. Gardner's voltage figures. That difference

Dr. Carl F. Prutton

in voltage, that slight difference is a few hundredths of a volt and it might be caused by a slight difference in the steel or the lead.

The Court: Yours is about twice as much. A. Yes.

Mr. Lyon: .14 and .086. A. It is almost twice.

The Court: Yours is almost twice as much.

Mr. Lyon: About two-thirds as much. A. Yours is about two-thirds of what we found.

Mr. Lyon: That is right. A. But I say both of them are negligible in a galvanic sense.

Mr. Lyon: Then the affidavit continues:

"That he has conducted experiments to determine whether the corrosion of steel in hydrochloric acid is greater or less when connected to a lead plate as follows. Weighed steel electrodes as in the voltage experiments above were coupled with lead and immersed in hydrochloric acid solutions. After measured periods of time the steel strips were removed, wetted areas were measured, strips were washed, dried at 105° C., and weighed. The losses in weight (milligrams) per square centimeter of electrode area were computed. Companion steel strips not coupled to lead were subjected to the action of the same solutions for the same periods of time, and weight losses per unit area likewise computed. The percentage reduction in corrosion occasioned by coupling with lead was determined as follows:

% corrosion reduction=

$\frac{\text{mg./sq.cm. (coupled)} - \text{mg./sq. cm. (uncoupled)}}{\text{Mg./sq. cm. (uncoupled)}} \times 100.$

Mg./sq. cm. (uncoupled)

"Data obtained in typical cases follow:

Then follows five columns headed "% HCl by weight," "Time hrs.," "Loss of weight of steel mg./sq. cm. coupled to lead," "Loss of weight of steel mg./sq. cm. not coupled to lead," and "% reduction in corrosion due to coupling with lead."

I am only going to read the first column and the last column because the middle data is not needed here. For

Dr. Carl F. Prutton

13.47 hydrochloric acid, per cent reduction in corrosion due to the coupling with lead was 93.5. For 14.7 per cent hydrochloric acid, the per cent of reduction in corrosion due to coupling with lead was 97.0. For 13.7 hydrochloric acid—

The Court (interposing): That is right back where the first was.

Mr. Lyon: The first, the time for the first was six hours, the first two, both of them were six hours. Over a period of six hours.

The Court: All right.

Mr. Lyon: Now, the next two are for a period of eighteen hours, three times as long.

The Court: All right.

Mr. Lyon: The next item, 13.7 is 92.4 per cent reduction in corrosion due to coupling with lead. And the next item, 14.7 per cent hydrochloric acid shows 93.5 per cent reduction in corrosion due to coupling with lead. Then the affidavit continues:

“That the textbook of Inorganic Chemistry by Partington, published in 1927 by McMillan of New York, which gives the electromotive series of metals as listed by the examiner in the Office Action of August 16, 1938, is correct only under certain specified conditions and under other conditions the electromotive series there listed is not correct. The table listed is the table of ‘normal electrode potentials.’ The normal electrode potential is the potential exerted between a metal and its ions when the activity of the ions is unity. (See: Outline of Theoretical Chemistry, Getman and Daniels, 6th Edition, John Wiley and Sons, 1937, pages 429 and 430.) If the activity of the metal ion is decreased the electrode potential at the boundary between the metal and the solution of the ions becomes more electronegative (Loc. cit. page 439). There are numerous ways of decreasing ionic activity. One process causing profound decreases in ionic activity is the formation of a complex ion or molecule involving the metallic ion. The commercial cyanide process for gold recovery from low grade ores utilizes the change in electrode potential brought about by formation of a com-

Dr. Carl F. Prutton

plex ion from gold and cyanide ions. The normal electrode potential of gold is ca. 1.5 volts electropositive to hydrogen. In a solution containing an excess of cyanide ion, however, gold is electronegative to hydrogen. (See Cyaniding Gold and Silver Ores, Julian and Smart, Lippincott, 1907, Pages 69-72, incl.)

"The normal electrode potentials of zinc and copper are 1.1059 volts apart. Upon addition of an excess of cyanide ion to a solution of zinc and cupric ions the resultant electrode potentials of the two metals against the solution are of the same numerical order due to complex formation, making possible simultaneous discharge of the two metals from solution in commercial electroplating of brass. (See Applied Electrochemistry, Allmand and Effingham, Longmans Green, Second Edition, 1924, page 358.)

"Authorities are in agreement that a complex of some type is formed when lead reacts with hydrochloric acid. (See Mellor, A Comprehensive Treatise of Inorganic and Theoretical Chemistry, Longmans Green, V. VII, 1927, p. 714; Treadwell, translated by Hall, Eight English Edition, corrected, John Wiley and Sons, p. 218), although the exact nature of the complex is not established.

"Iron does not form a complex ferrous ion in HCl solution. When Pb and steel electrodes are immersed in HCl solution, and coupled, the lead electrode, due to the complex discussed above, is electronegative to the steel electrode, as shewn in the table of voltages above and as indicated by the corrosion results cited above.

"F. T. Gardner.

"Subscribed and sworn to before me this 27 day of August, 1938.

"C. L. Thompson,
Notary Public."

Mr. Lyon: Now, I don't see anything in Dr. Gardner's affidavit here that has any of the iniquities about it. As you see, this current extends down an oil well pipe; he hasn't said anything about that. He has just established

Dr. Carl F. Prutton

the voltage and the direction of the flow of current in the electromotive series, and I don't think the witness has seriously disagreed with him on that.

The Court: He disagrees as to these results obtained here, as I understand. A. You have gotten out of me some preliminary work that we did in which I told the court that I disagreed—that I agreed quite closely and in general in the voltages. And then we ran a few inhibitions, and we got practically zero inhibition instead of 90 per cent.

The Court: That is where he disagreed.

Mr. Lyon: I see. A. They are preliminary results. But they indicate that with certain types of metal you get a slight inhibition.

The Court: You might have to disprove it; it isn't very severe, because there are so many chemists and you have so many you can readily run any, if you want to show me that that is the results you have obtained.

Mr. Lyon: Very well.

The Court: I think you intend to do that.

Mr. Lyon: That is right. But I want to point out Dr. Gardner, in talking about inhibition, percentage of inhibition, I don't think he was talking about oil well pipe. A. No, I don't think so.

Mr. Lyon: I think he was talking about the tank. A. Yes.

Mr. Lyon: He disagrees with him about the tank. A. I say we don't. I say we ran a few preliminary tests and the tests showed some inhibition when we used a piece of steel and covered the strip of it in the beaker with the lead sheet, we got 30 or 40 per cent inhibition. And when we used a sheet of strap steel we got no inhibition.

Q. But your tests have not gone far enough so as to disagree as to these values reported by Dr. Gardner as they apply to the tank rather than to the tube? A. I would say that from 95%, that is a tremendously high figure. I just can't see how when I got zero on several tests, 30%, approximately on another test, all of a sudden it is going to jump up to 95%.

Dr. Carl F. Prutton

Mr. Lyon: We have witnesses, Your Honor.

The Court: There is something funny in there as to why one gets zero, the other 93.

Mr. Lyon: That is pretty nearly as far as you can go. Only seven more. A. These are simply preliminary tests. I seriously question—

The Court (interrupting): How can you get zero if there is quite a lot there? A. Those are the results we got on this test.

Mr. Wiles: These tank tests showed a considerable pick-up in the iron in the tank which showed there was a lot of inhibition left to be done. Every time they put acid in the Menaul tank they picked up a lot of iron in it, showing the tank was being eaten away.

The Court: What kind of a test did you make when you practically got no inhibition? A. We took a sheet of strap iron, cleaned it up, as I recall, by sand-blasting or emery cloth.

The Court: As I understand, you followed as near as you could the teachings of that affidavit? A. Very similar, even closer together than that affidavit showed.

Mr. Lyon: I haven't found the results of those tests you last referred to in Exhibit 190. Maybe they have been made since this book was written up. Are they in this book 190?

Mr. Lightfoot: I believe they are. A. See page 9 for data, it says here (witness reading from book).

Q. That is part of Dr. Bartell's report that you originally started with. A. Oh, yes. 245 and 249.

Q. That seems to be (looking at book) that very queer apparatus that you said wouldn't work. Is that what you are basing that on? A. We ran a piece of lead in here (indicating) connected directly across with this piece of tubing, and we determined the inhibition. We put one strip of lead in here (indicating) and this section of oil well tubing with an extended arm on it and connected across between the two and found that when we connected it we got a reduction in attack of this piece of tubing of about 30%. I have the figures right here. Then we ran a test using

Dr. Carl F. Prutton

strap iron and putting the strap iron about an eighth of an inch away from the lead strip and inserted it in a beaker with a screw connecting up outside of the solution, and we got practically zero.

Q. What conclusion can you draw from that? A. I can't tell you. It was a preliminary test. When you asked me about whether the lead would protect the tank, I said it probably would to a limited degree.

The Court: Well, how do you explain in one you got about 30% inhibition and the other practically zero? A. Two different kinds of metals.

The Court: Is that the explanation? A. Possibly. The shape of the metal is different in the oil well tubing where we got inhibition. In other words, it was round. We had a strip outside here (indicating). It differed somewhat from Gardner's test. We got inhibition there.

The Court: When you got 30% were you nearer to Gardner than the other? A. Gardner reports 90 plus per cent.

The Court: I don't mean that. In the performance of the test. A. The one we got zero we were closer to Gardner in the method of performing his test.

Mr. Owen: In the one you got zero did you follow Gardner? A. Very similar. Two strips of lead, and we put them closer together than Gardner shows.

Mr. Owen: And did you connect them? A. Connected them together.

The Court: Don't tell me the differences now but tell me to what you yourself now attribute the different results in your two experiments where in one you got 30% and the other something else. If there are differences, you know; don't tell me the difference. Just tell me to what you attribute that difference. I want to get your idea. A. I imagine there is difference between potentials between the lead and different kind of iron.

The Court: You think it resulted from the different kind of lead you used and different kind of iron? A. Yes, and a matter of the difference in potential.

Dr. Carl F. Prutton

The Court: Have you told on the record what that difference was? Does the record now show? A. I don't recall. You mean in these little tests?

The Court: You attribute your difference in one case you got practically zero, the other case you got practically 30% inhibition, and you attribute that difference to the difference in the kind of iron and the difference in the kind of lead used in the two experiments? A. I believe that was the reason.

The Court: Tell me, then, what kind of lead and what kind of iron you used in the experiment where you got no appreciable inhibition. A. That was a sample of strap iron.

The Court: And what kind of lead? A. And the lead was chemical lead, I believe.

The Court: Chemically pure lead? A. No, a chemical grade of lead, just the kind they use in the bottom of these Menaul tanks. It was not chemically pure. It was the chemical grade of lead which they use in the Menaul tanks in the field.

The Court: All right. Now, tell me what kind of iron and what kind of lead you used in the experiment where you got practically 30 per cent inhibition? A. That was this oil well tubing cut out of lengths of this 1¼ inch tubing, and the lead was the same exactly. I think it was the same, strip, wasn't it?

Mr. Lightfoot: No. A. It was off the same piece.

Mr. Lightfoot: A lighter grade of lead. A. Was it the same kind of lead?

Mr. Lightfoot: Yes.

The Court: You don't attribute it to the difference in lead? A. No, not to the lead, to the iron.

The Court: You attribute it entirely to the iron? A. Yes.

The Court: In other words, one was easier biting for the HCl than the other? A. That probably was it.

The Court: Well, all right. A. I hate to make real definite statements on three laboratory tests.

Dr. Carl F. Prutton

The Court: Your best explanation you can give me as to why— A. (Interrupting): I don't like to go on record as making any hard and fast numbers.

The Court: I understand that.

Mr. Lyon: Now, also there was furnished to us in response to our request for additional reports, if any, correspondence, six binders which don't seem to add very much in so far as some of them are concerned, to Exhibits 184 and 185, because they seem to be preliminary copies of those, but there are some additional statements I would like to call Your Honor's attention to. This binder I have here, which is entitled "Progress report on Menaul test, submitted by C. F. Prutton, March 1, 1940," is a copy of a report that you submitted to the Dow Company on that subject on that date? A. Yes.

Q. And it covers largely the same material which is now incorporated in PX-185? A. That is correct.

Mr. Lyon: I call your attention to the last page, which is entitled "General comments." "No. 1. The rate of attack of hydrochloric acid on various lengths of tubing seems to vary considerably from length to length and be quite dependent upon the method of cleaning the metal surface." Was that a correct statement of what you had found up to the date of this preliminary report in your test? A. I believe it was.

Q. And is it still a correct statement of your observations? A. I think so, yes.

Q. "No. 2. In duplicating the Menaul procedure the amount of inhibition exhibited was much greater than would be indicated by the chemical inhibition shown by the entering acid."

Was that likewise a correct statement of what you had found at the date of this preliminary report? A. I don't recall. I don't think so.

Q. You don't think that statement is correct? A. I don't recall. This report was written—may I ask Mr. Lightfoot? This was written before we ran these analyses for the improved new method?

Mr. Lightfoot: They were.

A. This report, on this preliminary report we ran the iron determinations by this inaccurate method with lead in them, and the conclusions would be based on that, and if that is the conclusion, why it was corrected when we received the analyses on the acid samples, and those analyses were repeated at last Christmas time, very close to Christmas.

Q. After and subsequent to your submitting this report, preliminary report of October, 1940, to the Dow Company,—I believe you submitted it to Mr. Rebbeck, did you not? A. I think they went to Mr. Rebbeck.

Q. Did you receive any communication from Mr. Rebbeck or have any discussion with him about the contents of this preliminary report? A. I don't recall definitely the conversations. I believe I talked to him about every report we sent to him.

Q. Now, as a result of some conversation or some communication, you were asked to do something to produce a different result from the one that I have just indicated, were you not? A. No, sir; that was not the case. The case is that we kept on working on the problem and we discovered these errors and we corrected them.

Q. This last comment, No. 2, that I read to you, which you state is not correct, in your opinion? A. I don't recall. I would have to look through this report.

Q. That is just contrary—wait until I finish my question, please—is just contrary to what you have reported in Exhibit 185, is it not? A. It is contrary, the statement.

Q. And you corrected that as a result of going out and getting some different method or new method after the date of this preliminary report? A. A correct method of analysis.

Q. Well, isn't it quite true that Mr. Rebbeck indicated that something like that would have to be done, because he couldn't use the results as you reported them in your preliminary report in this case? A. Absolutely not. Mr. Rebbeck didn't indicate that at all, and we continued

Dr. Carl F. Prutton

doing work to accumulate more data, and this report is on the results of a few of those very preliminary tests. I don't know how many tests there are in this report. Can you tell, Bill? You are the one that got the report together?

Mr. Lightfoot: They are all different sections of tubing, I believe.

A. I think these runs could be—this could be very well explained. It will take some study to do it, and I don't think the conclusion is valid at all. I would like to take this overnight.

Q. Sure. Doctor, if you have anything you want to correct in anything you have said on cross-examination, why I am sure I want you to have an opportunity to do it, and if you let me know why I will ask the court to allow you to be given that opportunity. Now, I did ask yesterday—

The Court: All witnesses in my court can do that. I am looking for the facts, and that is all.

Q. Plaintiff's counsel didn't let me have the correspondence between this witness and Mr. Rebbeck. A. I have that. Do you want it?

Q. In view of the fact it is referred to at several points in Exhibits PX-184 and 185, I would like an opportunity to review that correspondence to see what the views are that were exchanged between this witness and Mr. Rebbeck in regard to the work that was to be done, and what the results were. Is this the complete correspondence? A. That is the complete file of correspondence to everyone connected with these tests, I mean, not only to Mr. Rebbeck.

Mr. Lyon: I will examine this this evening, Your Honor.

Mr. Lyon: Now, have we, as a result of PX-184 and 185, and these notebooks, and these additional preliminary or tentative reports that you furnished me, before us for study all of the experiments, and all of the work that you have done for this case, at least up to the start of the trial?

A. Up to the start of the trial, or just shortly before. We have some laboratory inhibition tests that were reported in

Dr. Carl F. Prutton

the presence of oil that are not in these books, and they were completed after the start of the trial, and the books were not available to put the data in.

Mr. Lyon: I think that that is as far as I can go with my cross-examination, and I may not have any more; but I would like to look over this file of correspondence tonight, Your Honor.

The Court: All right.

Mr. Lyon: I am returning to counsel the six partial reports, or preliminary reports, and one of the two volumes he gave me is an empty book, except for two or three pages.

I am going to ask that the court receive as Exhibit DX-190 the original record book which I examined the witness on, and there is nothing in it except practically this data on this case.

Q. Dr. Prutton, I don't believe you testified to any determinations made as to the percentage of corrosion reduction or the percentage of inhibition of the Halliburton storage tank acids. Did you make any such tests of the acids that you made to simulate them? That is the acid in the storage tank before it is acted upon in the transportation tank. A. I don't recall that we did. If we did that it was some isolated test that we made, and we did so many of them.

Q. Do you know a Mr. Harold Robinson of the Dow Company? A. Yes.

Q. What is his position in the Dow Company? A. He is a physical chemist, in the Physics Laboratory there.

Q. I show you in your file of correspondence a letter addressed to you, dated September 12, 1939, signed by Mr. Harold Robinson. Did you receive that letter from Mr. Robinson? A. Yes, I received that letter.

Q. And the letter contains this statement, does it not, "We would prefer to use the same commercial acid (General Chemical Company, Chicago) as was used by Halliburton in the well treatments with which we are concerned, if we could be sure that the acid would have inhibition of the same order (10 to 15 per cent) as the Halliburton stor-

Dr. Carl F. Prutton

age acid. We have observed occasional high inhibition in this and other commercial acids. I should say that there might be an advantage to using Graselli acid in that you would probably have a chance to check on the inhibition before buying it in any large quantity." I have correctly quoted the letter, have I not? A. I don't recall.

Q. Just read it over, if you will. A. You quoted correctly from the letter.

Q. Now, you understand from this letter that the Halliburton acid corresponding to that used by Halliburton in the well treatments which had been sampled was acid from the General Chemical Company of Chicago, and was inhibited and contained in its raw state inhibition as high as 10 to 15 per cent, did you not? A. Well, the story of the initiation of this work is not simply—cannot be taken from one letter. There were a series of conferences and discussions that were held between myself and Mr. Chamberlain, and also Mr. Rebbeck.

Q. I asked you if you had that understanding of this paragraph. If you will just answer that question, then we will get along to another. A. I didn't pay any attention to that paragraph.

Q. You didn't? A. No. I did not pay attention to a lot of things that Robinson told me to do. He was a sort of an assistant in the laboratory with Mr. Chamberlain, and instead of specifically following his instructions I took more of my general directions from these conferences with Mr. Chamberlain, who was his superior. Robinson suggested, for example, a tremendous amount of electro-potential work that would have taken months and years and many men to do, and I simply didn't follow that.

The Court: Is Robinson still with the Dow Company?

A. Yes, he is.

Q. Who suggested that you make your comparisons and your experiments with Graselli acid, which, as you have suggested, was practically chemically pure, rather than with raw commercial acid of the type used by Halliburton, which in its raw state was 10 to 15 per cent in-

Dr. Carl F. Prutton

hibited? A. Well, I can't enlighten you upon that. You found in our books and we evidently ran inhibition tests on this Penn Salt acid and Graselli acid and found some slight inhibition, and the purpose of the tests, as I saw it, and I was given quite a good deal of latitude, not at all times specific instructions from these men at Dow. I received letters from Robinson with many detailed suggestions, but I followed very few of them. I don't recall hardly any that I followed. The outline of the whole problem, the general problem was to determine if in a large scale set up these metallic components would greatly inhibit the acid and to determine the effect that this lead plate in the Menaul process had contributed to that inhibition, or whether it contributed at all. And the decision to use the acid, we must have discussed, for I ran this Penn or our men ran this Penn Salt acid. That must have been discussed in one of these meetings or conferences we had, and here with two types of commercial acid, and then with Graselli's very close to us, and in my opinion it made no difference, practically, as to the finding of this work, the general findings, as to whether a considerable amount of lead and some copper in the acid would greatly inhibit—increase the inhibition of commercial acid when run through a pipe system. That I think we have done and I think is independent of a variation in some small percentage in the acid inhibition.

Q. I show you a letter under the letterhead of The Dow Chemical Company, addressed to you, "Re: Acidizing Contact Time" signed by Mr. J. Rebbeck, Patent Department. Did you receive this letter? A. I did receive it.

Q. Is this Mr. Rebbeck's signature? A. It is.

Q. Mr. Rebbeck is the witness who was here on the stand sometime ago in this case. A. Yes.

Mr. Lyon: I want to read this letter to the court. It is dated January 24, 1941. In reading it to the court I will ask the court to have in mind the Dow men were present at these wells where they have obtained these samples, so they have full information as to the facts that are reported in this letter by the Dow Company.

Dr. Carl F. Prutton

Mr. Lyon: I think I will offer in evidence the previous letter dated September 12, 1939, from Mr. Robinson to Mr. Prutton. With the understanding if you don't want to destroy the file, the reporter can copy it in.

(Whereupon the document above referred to was marked DX 221, and reads as follows:

"THE DOW CHEMICAL COMPANY

Midland, Michigan, U. S. A.

September 12, 1939.

"Dr. C. F. Prutton,
Case School of Applied Science,
Cleveland, Ohio,
Dear Dr. Prutton:

"We have already forwarded to you under separate cover data relative to the composition of Halliburton lead and that section of the depositions dealing with the layout of the truck tanks.

"As for the ratio of Pb area to Fe area and the composition of the steel used for the truck tanks, I am asking Conner to get this data as soon as possible. We should be able to get the Pb-Fe area figure without much trouble, but as to the other item there may be some delay. I assume that in the case of the steel analysis you are mainly concerned with the copper content, insofar as it will determine whether or not your tank produces an acid having approximately the same copper content as the Halliburton truck acids. (We have some experimental runs which show that the copper in the acid is derived from both the lead and the iron, for a well tubing—Halliburton Pb couple in 15% HCl.) In order to avoid having to duplicate the steel from Halliburton's tanks, we might substitute for Test Run C a run similar to B, except that the acid in the crock would be synthetic Halliburton truck acid, i. e., metals added, which would be run through the steel tank rapidly as in B in order to avoid further metal pickup. That is, the inventory in the steel tank would be kept just high enough to allow for siphoning and getting the electrical output of the

Dr. Carl F. Prutton

couple into the tubing, possibly a 20-gallon inventory or thereabouts. I take this to be what you have in mind for Test Run B. With this procedure, we need only be concerned with avoiding an excessively high copper steel. So far as I know the electrical output of the cell is not going to be appreciably affected by the usual variations in steel composition.

"The tubing you require can be purchased from the Oil Well Supply Company, which has supply houses at Pittsburgh, Oil City, Franklin, and Butler in Pennsylvania and at Wooster and Newark in Ohio. This tubing is made by the National Tube Company.

"Bartell has been using 2" API seamless tubing. The smallest tubing of this kind available appears to be 1 $\frac{1}{4}$ " nominal (1.38 I. D.), but to get this under A. P. I. specifications it is necessary to take an external upset joint, which you will probably only cut off anyway to get steel samples. The specifications for this tubing are as follows:

"National A. P. I. External Upset tubing (quantity required), 1 $\frac{1}{4}$ " (nominal), 2.34 #/ft. with threads and upset without coupling, seamless, external upset, grade C. Specify length wanted.

"The same tubing without the upset and lacking A. P. I. recognition or approval is sold at National Oil Well Tubing, 1 $\frac{1}{4}$ ", 2.27 #/ft., seamless, plain end, grade C. According to the catalog data, this tubing is the equal of the A. P. I. tubing as regards thickness, test pressure, tensile strength, bursting pressure, etc., and has the advantage of having plain ends from which samples may be cut off without sacrificing a special construction.

"Dr. Bartell has not indicated what grade (B, C or D) of tubing he is using. Usually when this is not specified, the distributor supplies grade C and I assume this to be the case here. I will confirm this as soon as I can reach him.

"Tubing is supplied in two ranges of length: range 1 averages 21 feet with a minimum of 20 feet and a maximum of 24 feet. Range 2 averages 28.5 feet, maximum of 32 feet,

Dr. Carl F. Prutton

minimum of 24 feet. Tubing will also be cut to length when so ordered.

"We would prefer to use the same commercial acid (General Chemical Company, Chicago) as was used by Halliburton in the well treatments with which we are concerned if we could be sure that the acid would have inhibition of the same order (10-15%) as the Halliburton storage acid. We have observed occasional high inhibition in this and other commercial acids. I should say that there might be an advantage to using Grasselli acid in that you would probably have a chance to check on the inhibition before buying it in any large quantity.

"We will arrange with Dr. Bartell to have him send you the corrosion strips for inhibition testing. It would be advisable, however, to cut off a small section (at least 4" long) from each pipe section that you use and to have the former cut up into corrosion strips which could then be checked against Bartell's material. In any event, it would be a worthwhile precaution.

"I am enclosing some notes and comments on the setup and tests which you propose to use. We hope they will facilitate the work and possibly help you to avoid some trouble.

"Very truly yours,
The Dow Chemical Company,
"Harold Robinson.

"cc:
C. A. Campbell.
L. C. Chamberlain."

The Court: The letter of September 12, 1939 as I understand it, is from Robinson to Dr. Prutton, is that correct?

Mr. Lyon: That is correct.

The Court: And the other one is January 24, 1941, DX-222.

(Whereupon Exhibit 222 was marked by the Reporter.)

Dr. Carl F. Prutton

Mr. Lyon: This letter of January 24, 1941, is addressed to Dr. C. F. Prutton, Case School of Applied Science, Cleveland, Ohio.

**"THE DOW CHEMICAL COMPANY
Midland, Michigan, U. S. A.**

January 24, 1941.

"Dr. C. F. Prutton,
"Case School of Applied Science,
Cleveland, Ohio.
Dear Mr. Prutton:

"Re: Acidizing Contact Time.

"Pursuant to a suggestion made by Mr. Owen recently to examine the data in the Halliburton reports on well treatments performed by them and observed by us, I have ascertained from their tickets the approximate time during which the acid introduced into the well was in contact with the well tubing and the rate of flow of the acid through the tubing. The following is a tabulation of the pertinent data, which is taken directly from the Halliburton acidizing tickets for three wells. I have added a column of figures entitled "Gallons per Minute," which is the average rate of flow computed from the time and volume of acid introduced.

"Stella Wilcox No. 3

Time	Vol. Acid In	Pressure		Gal. per Minute
		Gasing	Tubing	
9:30 A.M. Start.....		0	0	
9:35 A.M. 500 gal.....		50	15	100
9:40 A.M. 1000 gal.....		100	15	100
9:42 A.M. 1200 gal.....		100	100	100
9:55 A.M. 2000 gal.....		100	400	65
10:30 A.M. 15 bbls. oil.....		50	700	
11:00 A.M. 25 bbls. oil.....		0	600	

Dr. Carl F. Prutton

Zahn No. 2 (First Treatment)			
11:00 A.M. Start	0	0	
11:03 A.M. 250 gal.	75	20	83
11:07 A.M. oil.....	50	500	
(Second Treatment)			
2:30 P.M. Start.....	25	0	
2:35 P.M. 500.....	50	205	100
Crawford No. 5			
12:20 P.M. Start.....	0	0	
12:30 P.M. 600.....	700	350	60
1:10 P.M. 1000.....	800	475	10
1:55 P. M. 1500.....	700	375	11
2:45 P.M. 2000.....	700	375	10

"From the foregoing information it appears that the contact time could be computed as being the difference between the starting time and that at which the whole charge of acid was in the well, and this assumes, of course, that it takes about as long to fill the tubing with acid as it takes to empty the tube after the charge of acid has been put in, an assumption which may not be justifiable in all instances. On the basis of this assumption the contact times would be as follows:—

"Stella Wilcox No. 3—25 Minutes.

"Zahn No. 2 (First Treatment)—3 Minutes.

"Zahn No. 2 (Second Treatment)—5 Minutes.

"Crawford No. 5—145 Minutes.

"The lengths of the tubing in each of these wells were 2600 feet for the Stella Wilcox No. 3 Well, 2600 feet for the Zahn No. 2 well, and 2676 feet for the Crawford No. 5 Well. This was 2 inches 4.6 pounds Spang API lapweld Range 1 pipe, the I. D. of which is 1.995 inches.

"We are concerned as to whether or not the observed inhibition values in your experiments (which are computed on the basis of the relative amount of iron picked up by raw acid solution compared to that of Menaul acid solution in passing through the experimental pipe) would show substantial or similar values of inhibition if the time of contact and rate of flow and pressure were made to cor-

Dr. Carl F. Prutton

respond exactly with those involved in the foregoing well treatments. It may be desirable to perform some additional experiments wherein the flow rate and time of contact, and possibly even the pressure, exactly parallels one or more of the Halliburton treatments for which we have data. If under these conditions a substantial inhibition is found, the experiment would tend to prove the acid is inhibited in actual practice of the Menaul process in wells. Please let us have your views as to this.

"Very truly yours,

J. W. Rebbeck,
Patent Department."

Mr. Lyon: At the adjournment last night I had just read Mr. Rebbeck's letter outlining the times of the contact of the acid in the pipe, in the three wells that the samples were taken from; it has been referred to in the evidence here as his suggestion that you run experiments to see what you would find the relative inhibitions to be under those conditions. Now, the only experiment that you referred to, I believe, in your testimony, or that is covered in your reports, where you attempted to run the acid at a different rate than one gallon per minute, was an experiment in which during half the time you ran it faster, but I believe you had no measurement of just how fast, and you did not make any determinations. That is correct, is it not, Dr. Prutton? A. That is correct, but there was oil present.

Q. Now, I find in this book of correspondence a carbon copy of a letter dated February 19, 1941, addressed to Mr. Rebbeck, and signed in typewriting "C. F. Prutton." Is this a carbon copy of a letter which you sent to Mr. Rebbeck in reply to the letter that I read last night (showing the document to the witness)? A. Yes, that is a reply, and is—

Q. (Interposing): I will read it, and then we will discuss it. I will ask to have this carbon copy of the letter marked DX-223.

(The letter above referred to was thereupon marked DX-223.)

Dr. Carl F. Prutton

Mr. Lyon: DX-223 reads:

February 19, 1931.

"Mr. J. W. Rebbeck,
"The Dow Chemical Company,
"Midland, Michigan.
"Dear Mr. Rebbeck:

"Attached are three copies of report on all data accumulated by us on laboratory inhibition tests. Several questions raised in recent letter from you, may be answered by this data.

"1. What is the inhibition of Halliburton's storage tank acid diluted to 4.3% N concentration?

"Page 7, Sample 2, is diluted C. P. HCl in distilled water, yielding 78.9 grams iron per meter per hour rate of attack. Sample 3 is 4.36 N Halliburton storage tank composition showing 52.5 grams iron per meter per hour. Per

52.5

cent inhibition is therefore 78.9 minus — times 100, which

78.9

equals 33. per cent."

I call Your Honor's attention that there is a determination by the witness that the Halliburton storage acid, on the basis of making these determinations, has a 33 per cent reduction in corrosion.

A. (Interposing): May I discuss that?

Q. (By Mr. Lyon): I will come back to this letter in a few minutes. A. All right.

Mr. Lyon (continuing reading):

"2. What inhibition would Menaul acid show if the acid treatment required as low as three minutes only.

88.

"Page 8 and first paragraph 107.0 minus — times 100

107.

equals 17.8 inhibition in three minute test, since Menaul

22.5

acid showed 72.5 minus — times 100 equals 69.0 per cent

72.5

inhibition in a three hour test.

Dr. Carl F. Prutton

“However, a three minute acid treatment would require high turbulence in the acid contacting in the tubing, thus differing widely from the static conditions in these laboratory tests.

“3. Comparison of analysis of Menaul tank acid with time of standing in special tank.”

And I am not interested in the reading of that third subject at this time.

The Court: When he says Menaul and Halliburton, he is talking about the same thing?

Mr. Lyon: When he was talking about the Halliburton acid in the first place, he was talking about the tank acid, I mean the storage acid, storage tank acid, and when he talked about the Menaul tank acid he was talking about the transportation tank.

The Court (interposing): What I have is difficulty in just grasping the theory.

(The Witness): May I explain it? Did you want me to?

Q. (By Mr. Lyon): I will ask you, to give you an opportunity.

Q. In the first place, Doctor, you did not report this data in Exhibits 184 and 185? A. No, because we felt it not representative.

Q. And you haven't revealed it in your testimony? A. I have revealed in general, not the specific tests. No, I haven't revealed anything about the velocities.

The Court: I am trying to get the theory of that letter and I will ask the witness if this isn't true—those figures that they give, those three inhibition results, wouldn't that mean two things: First, we will say it would mean that by the Menaul test it did increase inhibition and the longer it stayed up to a certain point, the higher inhibition. Wouldn't it show that? A. One thing I want to be sure you understand and get straight. The time he gives there is the time of contact of the acid with the tubing, not in the Menaul tank, but the contact of acid with the tubing. I want that thoroughly understood first.

Dr. Carl F. Prutton

The Court: All right. Now, that answers one thing. Now the other conclusion I drew from it is that you naturally would draw the conclusion from that that it was added to the storage tank acid because it couldn't be lower than it was before it left. Is there anything you can put in to increase inhibition? A. It has inhibitors added by contact with the Menaul tank. This is the storage tank at the station now.

The Court: And that shows a higher inhibition, that three minute test? A. I think you have got to compare the same time of contact with the same time of contact. I would like to explain that contact.

The Court: In other words, there are two different kinds of analyses, the first one the Halliburton tank acid is an analysis, that of qualitative of the same kind of analysis by taking that and testing it and by putting some iron in it and see how much, in that way? A. That is correct, except that I did not analyze the acid. We made up a synthetic acid to duplicate some figures that Mr. Rebbeck had given me and stated that that was Halliburton storage tank acid composition. He thought that and he said run it in your laboratories and test.

The Court: Is this your letter? A. That is my letter.

The Court: Where did you get the 33 per cent? A. We determined that.

The Court: In what way? A. By taking this letter of Mr. Rebbeck in which he said it is .93 per cent or parts per million of copper and Halliburton's storage tank acid they figured so many parts per million of lead, which I don't recall, and of iron, and with the chemically pure acid, and added to it the amounts of those metals to make up a synthetic mixture, which agreed with this analysis that Mr. Rebbeck stated to me was this storage tank acid.

The Court: Did you get that by putting some iron down in there? A. And then we took that acid which we made and put one of these collars of 1¼ inch pipe into it for three hours in our standard laboratory test procedure and determined how much iron it ate off, and it showed 33 per cent inhibition.

Dr. Carl F. Prutton

The Court: Well, between you, if your figures were right, you determined that Halliburton storage acid, if you didn't make any mistake, and everything just as you did, if they had that whole tank to use, and could and did put some iron in it? A. If the analysis was correct.

The Court: All right. That was the way I got the idea as to how that came. Now, how did you get—you got the next by letting it run past the iron for three minutes? A. No, we immersed this collar of tubing into the acid for three minutes and then withdrew it and determined its loss of weight in this inhibition test. We took acid which corresponded to the Menaul tank acid. That is the acid such as was found leaving the Halliburton tanks as it went into the well, with a collar of about three to four parts per million of copper, and three or four hundred of lead, three or four hundred of iron. We made up a synthetic Halliburton acid.

The Court: The way I understand inhibitions, and your finding about a quality of the solution, isn't that it? A. It is not always a solution.

The Court: You are using inhibition in an unusual way if you are talking about how much it is inhibited for that use at a certain length of time? A. It is inhibited, but it is tied in with the metal, and a number of other factors in the determination.

The Court: Do you mean the same acid there you found on one acid 17.8 and another 16.903? A. Yes, sir.

The Court: The same acid? A. Except that the time—

The Court: They were poor tests? A. No, no.

The Court: What acid is inhibited to a certain extent when the other is put in? A. That is it. It isn't per cent inhibition, or I should say per cent inhibition is not a constant.

The Court: You are talking about how much inhibitor we can have in acid? A. That is true, but the time of contact and the factors of the nature of the metal surface—

The Court: I take a piece of some acid and I put it down into a well, it don't determine how much it eats it, it determines the quality of that acid, when I start to put it down into the well, doesn't it? A. That is correct.

Dr. Carl F. Prutton

The Court: That is what I am trying to get at. A. There is no way we have of getting a number which is independent of other variables that expresses that inhibition.

The Court: Given a certain piece of acid, is it possible that science cannot tell me whether it is inhibited—not only whether it is inhibited, but the percentage of inhibition? A. It is not possible to tell you exactly the percentage of inhibition.

The Court: I want to get at my fundamentals here. I supposed— A. (interrupting): The percentage varies.

The Court: I had supposed after all of the testimony I have heard, that here is a gallon, or a barrel, or a million barrels of acid, all in one container. Now, understand, I am not talking about how difficult it is to do the trick, but I had supposed that that acid was either inhibited acid, or it was not inhibited acid, independent of any use, except as to iron—why, it is hydrochloric acid, and it is either inhibited as to iron, or it is not inhibited. Am I correct? A. That is right, that is correct.

The Court: Now, I am not talking about how difficult it is, but I had supposed that there was some way to tell the percentage of inhibition of that acid over there, independent of its use. It is hydrochloric acid, and it is inhibited as to iron, I supposed—we have agreed now that it is inhibited, or it is not inhibited; and then I come over to percentages, and I have supposed that as to iron it was inhibited, say, 30 per cent, or 70 per cent, or 15 per cent, or some certain per cent, no matter how difficult it is to obtain it, or what method you used, I had supposed that that was a characteristic of that acid, that is, that it would be correct to say—without saying how fast somebody is going to move it, or where they are going to put it—that I could say that it is inhibited, say, 37.5 per cent? A. You cannot do that.

The Court: Then I have got a wrong conception of inhibited acid. This is now in the fourth week of this trial. Somebody will have to tell me what—somebody will have to explain, when you say an acid has a certain percentage of

Dr. Carl F. Prutton

inhibition, what it means. A. I think your concept would be all right if you would follow it just a little further.

The Court: I understand that it will eat more or less, depending on how fast it moves. But another man will test it and get a different result then?

Mr. Wiles: His may or may not be parallel. He may have different figures.

The Witness: That is not correct. If you have a condition constant, then you are going to get the same thing.

The Court: Certainly, but, you take the same tank, one man will drive farther than another with it, and another man will take the tank of acid, fill it up, and drive a mile with it and dump it out. But another fellow fills the same kind of acid into his tank, and lets it stand all night and drives twenty miles and dumps it out. One acid is inhibited more than the other acid is.

I have had a different conception of it. I have had the idea that one acid—as I say, they are both iron tanks, which is the same kind of acid, only one tank goes farther. I have understood all the while this difference in results. I have understood that if you take an iron tank and put, we will say, chemically pure raw acid in it, and drive for just an hour and dump it out, you would not eat your tank so much as you would if you put that same acid in a tank, and let it sit all night and then drive a hundred miles with it and dump it out. I understand that the second acid would eat more than the other, although they were just alike. But, I have supposed that you could say that those two acids were inhibited to a certain per cent, and they were just alike, one was just the same as the other.

Now, I have talked about pure acid, but I will take one that is inhibited, I will say up to 20 per cent—they are inhibited to 20 per cent, and I put the same acid out of the same vat into two different iron tanks, transportation tanks. One of them I let sit there all night, and I haul it the next day, and at noon dump it out. The other one I haul promptly and dump it out.

Now, I have supposed that those two acids were in-

Dr. Carl F. Prutton

hibited to 20 per cent. I supposed that that could be determined. I have supposed that the one, because it was a longer time in contact with the iron tank, would eat more than the other. But, now, I find that I must not say that those two acids were alike, and each inhibited to 20 per cent. I must say that one of them was inhibited a short time to a lower per cent than the other one. Now, that is a fine definition that we have got, that is all I have got to say, talking about acid. If you eliminate the use of it as applied to acid at all, and apply it to results, and say acid containing this, in that length eats so much, or is inhibited from eating so much, I can understand it. But you have been using this as applying to the acid, the quality of the acid. Now, you cannot convince me that the quality of those two acids was not just the same. I have taken them out of the same tank, put them into two different iron tanks, and their inhibition was the same.

Mr. Wiles: Certainly.

The Court: And characteristic and strength and vitality, and if you want to apply this term to them you ought to work out some way of using that so that it wouldn't be so confusing as it is to say that one is inhibited to a great—you say one is inhibited to greater strength than the other, although I dip them out of the same tank? A. No. When you say per cent inhibition, I mean the time of contact which I ran the sample, the metal that I used, the temperature.

The Court: You are talking about results then, aren't you, and not about your acid? A. Absolutely.

The Court: Then apply inhibition to results and not to your acid, if it doesn't apply to the acid, am I not right about that? A. No.

Mr. Wiles: That is like every other thing.

Mr. Lyon: I should think the witness ought to answer first, because I don't know what the testimony of the witness is going to be.

Mr. Wiles: We have these material tests made by the A. S. T. M. and every one of them you adopt a standard test. We have an anti-knock test. You have got that test

Dr. Carl F. Prutton

in a standard engine, or it don't mean a thing. There is 78 octane gasoline and 72 and it means a definite thing, but it is only 78 if we try it in the standard engines at these times and temperatures.

The Court: Per cent of inhibition doesn't apply to the acid, does it?

Mr. Wiles: Just as much.

The Witness: Not solely to the acid, not entirely, but it applies to a considerable degree to the acid under definite conditions.

The Court: You are talking about a result, aren't you, when you say degree? A. Well, the result is what you measure.

The Court: You have got two acids that are just alike, you dip them out of the same thing, and you use them differently to get different results, don't you? A. Yes.

The Court: If there is a different percentage of inhibition in your acids— I dip them out of the same tank,—I use them different and of course I see that, don't think I am so dumb I don't see it get different results, but is there a difference in the acid in percentage of inhibition? A. Not fundamentally when you get back to the acid alone, unless you have these stipulated things. It is just a common practice, a method of measuring the reduction of corrosiveness of acid to specify under what conditions you run that test.

As Mr. Wiles explained, we say gasoline is 78 octane rated, and I think if you want to define that you would say that is an exact number, and that depends on the gasoline, and you could say, yes, it does depend on the gasoline, but when you describe that number you have to tell the dimensions of the engine, the temperature of the air, the exact, specific method of measuring that, and give about 101 different details, instead of five or six.

The Court: Well, if I want to measure something I recognize that you can standardize it and say that whenever we use that we refer to these specific conditions, and if you would only say or understand that we will say gasoline is of a certain test, or you can say what the temperature is,

Dr. Carl F. Prutton

so and so, and pressure is a certain thing, and other conditions, I recognize go in to make that which is standardized, and you can do that. If you don't, then I don't see how you can apply percentages to a particular mixture I have. You must go over to your results obtained, in my judgment. A. That is exactly what has been done here, I believe. We have reported per cent reduction in corrosiveness under specific conditions of test, and the question is whether the conditions of test have been in any way valid.

The Court: Now, I am not talking about results to defendant, because I think I understood all along your theory about that. We are just talking about what people mean when they say things. That is all the way this becomes important here on this record. You will find a lot of things have been said already about percentage of corrosiveness and comparing it with some other, to percentage of corrosiveness.

Now, does the defendant agree with the plaintiff that this term as applied can't be used at all unless you state what the conditions—that you can't tell the percentage of corrosiveness of a particular mixture that you have, and you can't be certain as to so many percentage of corrosiveness, or inhibition?

Mr. Lyon: We agree with that, with this meaning, that unless you specify all the conditions which would materially affect the value of the percentage, all those conditions which existed in the test, then your figure has no meaning at all.

The Court: Then you never could speak of an acid that is in a tank as being a certain percentage of corrosiveness, or a certain percentage inhibited.

Mr. Lyon: In other words, Your Honor, just to make it very simple, and take one factor, these results which they have charted here with these comparative charts only show these differences in percentage which would exist on a three hour test. They wouldn't—this chart wouldn't be the same if for some substantially different time, would it, Doctor?

The Court: I recognize that.

Dr. Carl F. Prutton

The Witness: I don't think it would, no. We haven't claimed it would.

Mr. Lyon: In other words, we don't care whether the acid is in there for three hours or for three minutes.

The Court: We never should say an acid is a certain per cent inhibited and stop there.

Mr. Lyon: That is right.

Mr. Owen: In order to show that this acid is inhibited we have conducted two kinds of tests. Dr. Bartell first conducted tests in which he took defendant's actual acids from their storage tanks and from their truck tanks, and he compared them, he tested them under similar conditions as to time, temperature, size of test piece and amount of acid, and he found that under those conditions the truck acids were inhibited much more than the storage acids.

The Court: Depending on how much they ate; that was all, wasn't it?

Mr. Owen: And another thing he did, in order to see what the effect of these small amounts of copper and lead and iron had, he made synthetic acids in which he started with C. P. acid and added these metals to that, and then he compared the corrosiveness of the C. P. acid with that of the synthetic acids under similar conditions.

Then Dr. Prutton took up the work, and Dr. Prutton also conducted two kinds of tests. First he conducted laboratory tests in which he followed generally the methods followed by Dr. Bartell, in which he made synthetic acids by adding to chemically pure acid these different kinds of metals.

The Court: Yes.

Mr. Owen: And he tested the C. P. acid and the synthetic acid, side by side, under similar conditions. Then, in order to come closer to actual field conditions he built up this apparatus which he has described, and he tested the Halliburton acids against commercial acid purchased from Grasselli Chemical Company, and he took a different standard. He did not take the C. P. acid. He took the commercial acid. And then he did two things. He built up

Dr. Carl F. Prutton

that commercial acid synthetically by adding metals in amounts comparable to those found in the defendant's acids, and he tested those through this apparatus, running it from a stoneware crock where there could be no change except that which took place in the pipe, and then he went further and he built a tank to simulate the Halliburton tank, and he put commercial acid into that tank and let it stand there for six and a half hours, and stirred it every fifteen minutes, so as to get as nearly as possible an acid that would have resulted had the commercial acid been carried in a Halliburton tank for six hours.

Then he ran that acid from this simulated Halliburton tank through the system, and he analyzed it to see how much copper or how much iron there was when it started through the piping system, and he analyzed it to see how much there was when it got through, and he took the amount of iron that was taken up from the pipe and compared that amount with the amount of iron that was taken up from the pipe with the commercial acid, without any additions, run from the crock through the pipe.

The Court: You take a given acid, and you run it for three minutes, you get a different inhibition than you do if you take the same acid and run it for three hours, don't you? A. That is correct. I have a chart of the inhibition against time, Your Honor.

The Court: All right. I follow that. Now, we will say you get 17.8 if you run it three minutes, and we will say that you get 69.03 if you run it for three hours? A. Yes.

The Court: Is it correct to say that acid is acid of a certain per cent inhibition, and say nothing more? A. No. We have got to describe the tests, and we have tried to do that.

The Court: If you put it in an iron tank and haul it for three minutes, you get a different result than you do if you put it in an iron tank and haul it for three hours? A. You get a different result.

The Court: Would it be correct to say that the acid

Dr. Carl F. Prutton

you put in a tank had the same inhibition, and stop there?

A. The acid is the same.

The Court: I know. Now, don't misunderstand me, I am just talking about how to talk about this thing, and how we have been talking about it, and get it on the record. I understand exactly now that it is going to eat more, the longer it is in there. I understand there are other things entering into it. I want to know whether it is correct to say that the acid had the same percentage of inhibition, if you put one in a tank and haul it for three minutes, and you put the acid in another tank and haul it for three hours. Is it correct to say—is it correct to use that term, that it has got the same inhibition? A. No, I would not use it. I would describe how long it was in the tank.

The Court: Well, in this record you will find that that is done. I am trying to get it clearly on the record, but you can't use that expression with reference to acid. It is only when you state all of the elements, according to your testimony, is that right? A. That is correct.

The Court: It depends, too—you take the same acids, and you take different kinds of iron—you go to two different places and get iron, and you put one into one vat of this same acid, and you put the other into another vat of the same acid, you get different results—your iron is different? A. Somewhat different, yes.

The Court: Then it is not correct to say that you take acids of the same percentage of inhibition, is it? A. No, not without explaining the tests and the results.

The Court: They have got different inhibitions, because you have used them differently? A. The popular conception of the term "inhibition" is—

The Court: Oh, I know, but I want to know just how wrong we have been in using the definitions here. We should not apply it to the acid when we get to percentages. You can say it is inhibited, that it is capable of inhibition? A. Yes.

The Court: But when you get down to percentages, you must not say it any more, is that right—we must stop

Dr. Carl F. Prutton

using it? A. With reference to a certain figure. You have got to define conditions, and the popular use of the term "inhibition" is an erroneous one.

The Court: Well, I take my acid, and I haul it in a wooden tank, nothing else touching it, only the wood—what is its inhibition? A. If I am to answer it, the way I would report inhibition—

The Court: Now just wait a minute. I did not take it out, I didn't do anything with it. A. I would say that you would have to take the acid out of that tank.

The Court: But I didn't take it out. You can't take it out of that tank. I have put it in there, and I keep it in there twelve hours, and I haul it all around. Now, I want to know whether it is inhibited, or not. A. And you take some out and test.

The Court: You have got to take it out and put it in with iron? A. Absolutely.

The Court: Then you can't tell how much, except that you state how long and whether it was agitated. They are just as necessary as those who describe the acid. A. Not quite.

The Court: How can you state percentages, one without the other elements? A. You can't.

The Court: If you keep it in the wood and don't let it touch anything else, what is its inhibition? A. You have got to run a test.

Mr. Lyon: The percentage of inhibition you get by that test will be different if you have two different kinds of iron that you tested on? A. It will be somewhat different.

The Court: All I am bringing out is now that the way we have been using the percentages don't apply to acid and the stuff that is in it. The percentages apply to the acid, that stuff that is in it, the time that is used, the agitation, and all the elements that figure into it, and it is only as to those results, in other words, that it applies, and that result and that percentage in the result is contributed to, I understand that fully now, and you don't need to worry about that, it is contributed to by the acid and it is con-

Dr. Carl F. Prutton

tributed to by the time, but whenever you use the term percentages you are talking about results and not about the things that go in to make the result. A. That is involved in it, but it is not the sole factor.

The Court: But you mustn't apply the percentage over to time? A. No, sir.

The Court: You mustn't apply percentages over to agitation? A. No, sir.

The Court: You mustn't apply percentages over to the acid? A. Not alone.

The Court: Not in inhibition now. Of course, you couldn't apply it all the time? A. You have got to take them altogether.

The Court: But when you come over to talking about percentage of inhibition of corrosion I must not apply that to the acid at all, and I must not apply it to whatever is put in as an inhibitor. All right. Now, we have got that, I think, clear on the record. A. It is a method of comparing acids under similar conditions, and that is all. I would like to answer the questions raised in that letter.

The Court: You mustn't say an acid is a certain per cent inhibited because no chemist is wise enough to determine that. Doctor, given a quantity of acid, you can't analyze that. A. Not without specifying the conditions. We can analyze it chemically.

The Court: Yes. But you are dealing with a proposition and you have used the definition as such after you have analyzed that you can't say it is a certain per cent inhibited. A. Not unless you make tests.

The Court: And then you get results depending on the condition. A. And comparison of one solution with the other.

The Court: Then it isn't comparable. Most things you take an analysis, you tell how much it is with this percentage. A. We have these chemical analyses. We say there is 1% lead. We determine absolutely. That is fixed on the sample.

The Court: Yes, I get that. You tell me the in-

Dr. Carl F. Prutton

gredients in it but when you talk about per cent inhibition you are not talking about the ingredients. A. No, talking about the performance of it under a definite test condition.

The Court: Then why don't we agree you are talking about results and not ingredients. Don't you agree with that? A. The ingredients contribute.

Mr. Lyon: All right, doctor— A. (interposing): May I explain the letter? We got sidetracked on the discussion.

Q. I will finish my part in a few minutes, and I will give you an opportunity then to explain, or they can.

The Court: I want to give you a full opportunity, doctor. A. Yes.

Mr. Lyon: I am going on with this, and it is not going to interfere, at all, I am sure.

Mr. Lyon: Doctor, when you reported the results of your tests to the Dow Company, you simply reported, did you not, the actual values that you found in the first instance? A. Why, I believe so. I always report results as to what I find.

Q. I mean the result, the measure—

Mr. Owen (interposing): I suggest that the witness be shown the letter that you are referring to.

The Court: Yes; he is entitled to see it.

Mr. Lyon: Yes, if there is anything he wants to see. A. What are you asking about?

Q. I am asking a physical fact now. A. The physical fact is that I report to a client sometimes in letters and preliminary statements, I report preliminary reports, and then finally when I get through summing up all the work that has been done, I arrive at some definite conclusion as to the results of the work and I report that. It has been referred to in the correspondence here.

Q. What I am getting at is this, doctor, these tabulations, such as PX-189, of the kind that were brought here, you did not prepare those at all? A. No.

Q. They were prepared by the Dow Company? A. Yes, that is correct.

Dr. Carl F. Prutton

Q. You were asked to include them in your report?

A. Not in my report.

Q. In Exhibits 184 and 185? A. Well, it is not bound in my report. They brought those charts in, and we checked the figures on them.

Q. Now, doctor, the various tables that were included in your report, those were also prepared by the Dow Company, were they not? A. Absolutely none of them. They were all prepared by us.

Q. You prepared these reports and submitted them to the Dow Company, but as they appear in Exhibits 184 and 185, they have been completely re-written from when you first presented them to the Dow Company, have you not? A. I presented interim reports, by just reporting whatever came at hand, to try to give them a picture, and letters were written as to little changes that might have been made, or little differences.

Q. You say they were only little things. Weren't you asked to leave out some things? A. There were a lot of small tests that were made, of various kinds, and in making the final report that was brought in here, and which I don't think we submitted as a display or an exhibit, but was taken in as an exhibit, that was written, specifically going at one particular object, not to include all of the little miscellaneous things that we arrived at on the side, or—

Q. (interposing): I am going to ask you if this is one of the letters that you received from Mr. Rebbeck with reference to the data or the report after you had submitted it. This is dated July 18, 1941, addressed to you, and signed by Mr. Rebbeck, on the stationery of the Dow Company (handing the document to the witness)? A. That is a letter that was sent to me, and we revised the report in line with this, and, as I recall, before that letter was written to me, I had had a brief conference with Mr. Rebbeck in Midland, in which he just went over this, there were a number of typographical errors, and we went over the form in which the final report was to be prepared.

Mr. Lyon: I will ask that this letter be marked DX-224.

Dr. Carl F. Prutton

(The letter above referred to was thereupon marked DX-224.)

Mr. Lyon: I will read this to Your Honor, it isn't long. I will read the first part of it.

"DOW CHEMICAL COMPANY, July 10, 1941.

"Dr. C. F. Prutton,

"Case School of Applied Science,

"Cleveland, Ohio.

"Dear Dr. Prutton:

"Subject: Changes in 'Memorandum reports on Halliburton-Dowell case' June 20, 1941.

"Mr. Owen has reviewed the subject report and would like the following changes made. Will you please retype the pages to be changed and furnish us with copies for our reports?

"The changes to be made are as follows:

"First, number all the pages beginning with the title, 'The Effect of Pressure on the Corrosion of Steel by 15 Per Cent Hydrochloric Acid containing Inhibitors,' but omitting the memorandum of report entitled 'The Effect of Crude Petroleum Oil on the Corrosion of Oil Well Tubing by 15 Per Cent Hydrochloric Acid.' With this section omitted, the title page 'Small Scale Tests That May Be Used To Demonstrate the Effect of the Menaul Process' will be numbered 5.

"Revise the table of contents by omitting the second item, namely, 'The Effect of Crude Petroleum Oil on the Corrosion of Oil Well Tubing by Fifteen Per Cent Hydrochloric Acid.' "

Then there follow several pages of changes. I guess I will have to put them all in, as the witness has attempted to deny the latest report in existence that this letter mentions.

Q. The first of these letters asking you to revise your report, and also stating—I think I will read the letter so you can identify it. This letter is dated July 9, 1941, from you to Mr. Rebbeck, is it not? A. From Rebbeck to me.

Q. You received that letter, did you? A. Yes.

Dr. Carl F. Prutton

Q. I will ask that this be marked DX-225.

(The letter above referred to was thereupon marked DX-225.)

Q. The next letter is—well, on the same subject there is another letter of the same date, is there not? A. Yes.

Q. You received that letter? A. Yes, I received that letter.

Mr. Lyon: I ask that this be marked DX-226.

(The letter above referred to was thereupon marked DX-226.)

Q. The next letter is the letter that I have already read, which is DX-224. I have already read that. The last letter is a letter dated July 11, 1941. Did you receive this letter from Mr. Rebbeck? Did you? A. Yes, sir, that is correct.

Mr. Lyon: This will be DX-227.

(The letter above referred to was thereupon marked DX-227.)

Q. With reference to these letters, or this last letter, DX-227, that is the letter in which Mr. Rebbeck suggested to you the use of average of averages, and the averaging of various tests for determining what 100 per cent corrosiveness is, and the various matters that are involved—he worked out this per cent of corrosiveness and asked you to adopt it. You didn't do that, isn't that correct? A. As I said, as I recall I met Mr. Rebbeck some time in June, and I think Mr. Owen was there, and Mr. Conner, and these changes were discussed, and this method of representing the results. These are not any faked-up results. It is just a different way of writing the results, changing from per cent inhibition over to this reduction in corrosiveness, a different way of expressing the results. I saw no valid reason as to why it could not be done, and they said, "We will calculate your results, and you check them, and we will have the figures made up for you." And that was the way it was done.

Mr. Lyon: I don't think that it is necessary to read each of these letters if they are here, Your Honor, except

Dr. Carl F. Prutton

I will indicate as to DX-225. It says: "Subject Correction to Report Entitled Large Scale Test of Menaul Method of Acidizing Oil Wells dated June 20, 1941. Mr. Owen has reviewed the subject report and proposes that you make the following corrections or changes and that you retype each page requiring such changes or corrections, furnishing us with the retyped pages for each of the copies of this report." And then there is tabulated as to what he wants done.

DX-226 starts out the same way—"Subject Changes to be made in the report entitled Corrosion of Oil Well Tubing by 15% hydrochloric acid June 20, 1941"—these changes are made after the date that appears in exhibits 184 and 185. The date of the report is June 20, 1941. "The following changes are proposed as a result of the review of the subject of this lawsuit"—

The Court: When did we start this lawsuit?

Mr. Lyon: July 21st. Then the letter contains 2½ pages of changes. I have read from DX-224. DX-227 is the last one, dated July 11, 1941, and reads: "Dr. Prutton, for the purpose of constructing charts, summarizing your findings as to the corrosiveness of commercial hydrochloric acid to which you added iron, lead and copper, I have made some calculations reducing this data to relative corrosiveness as follows"—and then includes preparation of these things. I mean his method of calculating these things. This is signed by Mr. Rebbeck to this witness. The letter concluded: "It will be desirable for you to be familiar with the origin of the figures appearing on the proposed charts, and for that reason I have given you the methods used in computing them. In addition, there is enclosed herewith a typewritten form which will represent substantially the layout of the completed charts. I believe you should check the computations to be sure that the figures are right. If you find any errors, please immediately advise. Mr. Rebbeck, Patent Department."

Now, the purpose of this is so Your Honor will understand and distinguish in this testimony between what was

Dr. Carl F. Prutton

this witness' experimental data and what is the form in which it is reported, and whose idea and whose responsibility the form of the reporting is.

I think that is all the cross-examination.

REDIRECT EXAMINATION

By Mr. Owen:

The Court: Now, Mr. Owen, don't forget to give the doctor the opportunity that I very earnestly promised him.

Mr. Owen: I will try to, Your Honor.

The Court: I want him to have every opportunity.

Mr. Owen: With the character of the cross-examination, Your Honor, it makes it necessary for me to review to a considerable extent what Dr. Prutton did in preparing his work in connection with this case.

The Court: I will leave that to you.

Mr. Owen: I am going back to the time when the matter of this work was first referred to you, Doctor. Can you tell about when that was? A. The earliest recollection I have is late in the summer of 1939.

Q. And was that in a conference or by letter, do you recall? A. Just in a conference and discussion with Mr. Chamberlain and Mr. Rebbeck.

Q. And thereafter what, if any, tests did you make prior to the time you made these pipe tests in which you built the duplicate Menaul tank? A. Well, I made no tests before we started in on this large scale work. The discussion that I had with Mr. Rebbeck and Mr. Chamberlain was that in connection with this case that Dr. Bartell had certain things to perform, and one of the jobs that somebody had to do was to make something other than a little piece of steel in a beaker, and run some tests to indicate what would happen in an oil well tubing under conditions that should be fairly well reproduced, and reported, and that would fairly well represent what might happen in running down the tubing of an oil well, and that those tests also should include an examination of just how this Menaul

Dr. Carl F. Prutton

process functioned, and what part of the reduction of corrosiveness was due to the Menaul process.

Q. Well, now, in your direct examination, you referred to three different kinds of tests, as I recall. Two of them were laboratory tests, one set of which used little strips of iron, and in the other set of which you used one-inch sections of this same oil well tubing which you used in the larger tests. Now, in respect to time, what was the relation between your laboratory tests and your large scale tests?

A. The laboratory tests that we finally adopted, and which are reported in the report as being comparable with the large scale tests employed a time of three hours for the test, and the time of the large scale tests was three hours.

Q. Well, that is not exactly what I had in mind. I am trying to get fixed in the court's mind the relative dates on which you conducted these three different series of tests. The two laboratory series and the large scale? A. Well, we started in to run the large scale tests and—those were the first tests we ran—and associated with the large scale tests we started testing the inlet acid with this laboratory test, using a very small specimen of steel and a very small volume of acid for a very long time of contact, thirty hours.

Q. And then, as I understand it, your first laboratory tests were made in connection with the acid you were using in the large scale tests? A. That is correct.

Q. I see. Now, before you started this large scale test work, did you outline any program and submit it to the members of the Dow organization who were interested in this matter? A. Following the first talk that I had with—there may have been more than one with Chamberlain and Rebbeck—they had indicated about in general what their problem was and they questioned whether Dr. Bartell, with the time available, and so forth, would be able to get around to make these large scale tests. I think they had that in mind when I first talked to them, that he would do the large scale work and the small scale work as well, that is, the analytical work. And, as I recall, they expressed some doubt as to whether he would get around to do it. And I

Dr. Carl F. Prutton

said if they wanted me to and thought it advisable that I would be glad to undertake those tests. And at the final meeting of those preliminary discussions they said, "Well, you write up what you think ought to be done and let's talk it over again."

And I wrote that up and that is included in this complete file of correspondence, a complete outline of what I thought ought to be done to examine, to ascertain and determine the reduction in corrosion caused by copper and lead in acid, in passing through a piping system, in determining whether the Menaul process had any effect on reduction in rate of attack of acid upon steel, whether the effect you obtained with a Menaul tank was a combination of the inhibitor effect plus the Menaul effect.

And the tests that were outlined included first a running of blank or fifteen per cent commercial hydrochloric acid through a fairly good length of oil well tubing. Second, to run the fifteen per cent acid into this simulated Menaul tank, agitate it for some time that would roughly approximate what agitation would be obtained in handling the acid from the storage tank to the well, and then operate the Menaul process on that acid, that is, to deliver the acid into the tubing and connect the wire up from the tank to the tubing and see what effect that had upon the rate of attack, whether it was reduced over the raw acid that went in without the Menaul tank.

And the next type of test was to run the acid from a stoneware crock directly into the Menaul tank and immediately out, so that we would eliminate this inhibitor effect and we would get only this electrolytic effect, the Menaul method of inhibition, electrolytic inhibition, acting to stop the acid from attacking the tubing.

And the last test was to be a test in which we would take fifteen per cent hydrochloric acid and incorporate into it the metallic concentrations which the acid had when it left the Menaul tank in the Menaul test and we would run that acid directly from the stoneware crock into the tubing.

Those tests were all outlined. And at the beginning of

Dr. Carl F. Prutton

the work, at another visit to Midland, that proposal was discussed and, as I recall, Chamberlain was the only one present then. He may have talked to Rebbeck. But he said go ahead with the work, and so we went ahead. The first thing that we did was to purchase a number of lengths of this oil well tubing. We purchased a convenient size stoneware crock which was about 250 gallons, and which was so big in diameter and about so tall (indicating), about four feet in diameter and maybe four feet tall, and we purchased the smallest size of oil well tubing simply so that we could get a fair rate of flow of acid in the tubing.

If we used two inch tubing or three inch tubing the acid would have been very slow in running through that tubing, and then the inch and a quarter was taken as the smallest standard commercial oil well tubing that we could obtain.

Now, we had in mind at the beginning of these tests that if we purchased the tubing from one lot of tubing that the attack would be fairly uniform. That is, that if we had one length of tube here with acid running through it it would attack that length at a certain rate and the next length would be attacked substantially the same. And we proposed, with that in mind, as I recall, we purchased 30 tubes with the idea of using 5 tubes in each of these 5 different tests, and then have some tubing left over for making elbows and connections and to cut up for inhibition tests, and so forth.

Q. May I interrupt you there, Doctor. The tests that you outlined in your testimony were five in number—the ones that you outlined as you have just described them? A. There was a raw acid, there was a Menaul process, there was a quick Menaul process in which we ran the acid immediately in and out, there was a Menaul without the wire connected, and there was a synthetic Menaul type acid—five different tests were proposed.

Q. And your original plan was to run each of those tests in a separate set of tubing? A. In a separate set of tubing. We thought the tubing would all perform exactly the same.

Dr. Carl F. Prutton

Q. And you originally bought enough tubing for the five tests? A. To run the five tests and have enough left over.

Q. Now, will you go on with your explanation? A. Now, we knew, of course, we had to adopt some fairly standard conditions of running the test and we had heard, as I recall through Mr. Rebbeck, that tests were being made at 85° F. by Dr. Bartell in inhibition, and it seemed to us it was a fairly good temperature to use. I don't think it was given any great amount of consideration because it seemed like a reasonable temperature and one we could obtain fairly readily in our laboratory. The tubing, the temperature was fixed in that manner, the volume of acid was fixed by this stoneware crock we had, and we simply arbitrarily decided that we would run through a gallon a minute and would get a test of about 3 hours.

Now, if you question the condition as to the three hours, one of the letters introduced here indicates that I knew the acid treatments that were made by these people were 3 to 25 minutes, or 6 to 25 minutes, but I knew that after the program was about 50 to 60% completed and I couldn't go back and do that over. There were many reasons why I couldn't do that over.

Q. Doctor, aren't you misquoting that letter? A. I don't recall. It was a short time.

Mr. Owen: It is set forth in one of these letters, I believe, and I want to get that right. Yes, it is set forth in the letter dated January 24, 1941, to you from Mr. Rebbeck, which is in evidence as DX-222. Now, in this Exhibit DX-222, the times are given as follows, summarized: Stella Wilcox No. 3, 25 minutes. Zahn No. 2, first treatment, 3 minutes. Zahn No. 2, second treatment, 5 minutes. Those were both one treatment, Your Honor. It was two sections of one treatment. Crawford No. 5, 145 minutes.

Q. Well, now, will you proceed? A. I did not pay a great deal of attention to that letter, simply because we had filled out most of our program on three hours, and I had felt that taking a three hour result would get approximately

Dr. Carl F. Prutton

what was done in shorter or longer times. We knew that we could not run a three minute test, because we got this peculiar effect of loose powdered metal that we could not remove from the surface, that came out during the first few seconds of the run, and we got a peculiar result there that we could only explain by imperfect cleaning of the tubing. On a run of a 3 minute test, the acid is actually—one particle of the acid was running through our tubing, and taking 10 minutes to go from the inlet to the outlet, so that it would be impossible for us to run a 3-minute test and get any significant values.

We did, however, study quite thoroughly later in the laboratory the effect of time upon the rate of attack of the acid upon oil well tubing, but that came later, and that came after Rebbeck's letter about the time of contact.

I knew nothing about the time of contact before that time, and the basis of the three hours was simply knowledge—I had been out on acid treatments, and hung around for six to eight to twelve hours waiting for the acid to go into the formation, and the general knowledge that I had of the various time that acid treatments required—I had that general knowledge, and the three hours seemed to be a fairly reasonable figure, and fitted in with the equipment that we had, the volume of the crock, and the diameter of the tubing.

Q. Doctor, I show you a carbon copy of a letter dated January 28, 1941, addressed to J. W. Rebbeck, and signed in typewriting by C. F. Prutton. Will you state whether you wrote such a letter? A. I did write this letter.

Q. And state whether or not that was in reply to Mr. Rebbeck's letter of January 24, 1941, which is in evidence as DX-222? A. That is in answer to his letter in which he mentioned the short times of contact.

Mr. Owen: Now, I will ask that this letter—

Mr. Lyon: May I see it?

Mr. Owen: You had it. It was right in a bunch of letters you had this morning.

The Court: PX-228 this will be.

(The letter above referred to was thereupon marked PX-228.)

Dr. Carl F. Prutton

Mr. Owen: Will you explain that letter, reading such portions of it to the court as may be necessary to explain the sketch that it contains? The date is January 28, 1941.

The Court: With such a short letter you might read it all.

Q. Read the whole letter.

The Court: And then explain it. A. (Reading):

"Dear Mr. Rebbeck:

"Our 3-hour tests duplicated fairly well the time of 145 minutes required on the test on Crawford No. 5.

"However, we have no large scale tests made in from 3 to 5 minutes such as occurred in tests on Zahn No. 2. Moreover, we cannot see how a 3-minute test could be made with our set-up. However, our laboratory tests show that during a test of short duration, such as 3 to 5 minutes—" we took this and put it only for a few minutes into the acid to see how the amount of iron dissolved compared with what would dissolve if we used the chemically pure acid—" * * * the percentage inhibition would be about the same as would be obtained in the 3-hour test.

"The rate of solution of the iron is greater in the short test than in the 3-hour test."

The Court: You better read that to me. A. I will read the whole thing.

"If you think that test on our laboratory tests which we have shown to agree quite closely with the large scale 3-hour tests would be sufficient we will re-check our preliminary figures and short-time laboratory tests to more exactly establish the above curves. If you think it imperative to run large scale tests please advise me and we will attempt it."

The Witness: Now, the letter shows a drawing, or a graph, which shows plotted horizontally the time of contact in this laboratory test, 180 minutes, which is out at the end of 3 hours. The rate at which the acid ate into the steel, expressed in grams of iron per square meter per hour is plotted vertically. And it shows that in the first few minutes of the 180 that there is a peculiar sharp dropping of that curve.

Dr. Carl F. Prutton

Q. What does that indicate? A. That indicates to me that that is that loose metal which we got on our large scale runs, or metal which is highly disturbed on the surface of the steel that simply wiped off by the first acid attack, and it is difficult to run a test of such short duration to get a valid answer. As soon as you go to a period of 8 to 10 minutes, then the curve becomes almost flat, and they show, the upper curve uninhibited 15 per cent C. P. hydrochloric acid.

The rate of attack of that is about 70 grams per square meter per hour and it eats into the steel at that rate. The rate of attack of the same Menaul acid is about 25, in other words, about one-third the rate of the inhibited acid.

In other words, going from 8 minutes out to 130, and we in subsequent work that is in that book that we had, our data book, we went out for 12 to 14 hours too, and those lines just kept on going out. We believed that that would fall off when you went out to a considerable number of hours, but from the period of 8 to 10 minutes and going on out through our 3-hour test, the reduction in corrosiveness, of the Menaul synthetic acid was only about one-third as corrosive as the diluted C. P. acid, and therefore this letter, I believe, convinced Rebbeck, or at least I don't recall he wrote me another letter telling me to go ahead with large scale tests. This indicated the impractical nature of it, and also that we were running short of time, and so forth, and I don't recall any other correspondence on that. That seemed to close the matter up.

We did run checking values to check these preliminary data that we have, and we have data that will establish the curve from three minutes on out to fourteen hours or so, and the curve is substantially of that shape, showing that the reduction in corrosiveness is substantially constant after ten minutes time, and we believe that that first part is due mainly to these little particles of iron that when we run our wire brush through the steel that those little particles of iron are just held on there by a thin piece of connecting iron or something, and any attack at all loosens it

Dr. Carl F. Prutton

up. We got a slug with highly concentrated iron out of the large scale tests, indicating that to be true.

Q. Go ahead. A. That time was one of the conditions of the test. Then we realized that the method of cleaning the tubes undoubtedly would exert a great effect upon the test results. In other words, the scale, and so forth, on the surface, that we had to adopt some standard procedure, and so in Test A we set up five lengths of tubing with an extra part to connect it up to the top, and then coupled it, and we had—we purchased this stiff, hardened steel wire brush, and fastened it on the end of a long iron rod, and one of the operators that was to make this test, one of them was assigned to the job of cleaning out this tubing, and after he had done it he insisted that we put another man with him, or two other men, and we used three men to get that brush, which is, when extended, about two and a half inches in diameter, to ram that through an inch and a quarter tubing. It was a stiff wire, almost like piano wire, and it took two or three men to get that through and to do it in a reproducible manner. But he finally got it through and ran it through twice, which was the number of times that we used in later tests in the remaining use of the tubing.

Now, the rest of the method of the cleaning was essentially the same as we used in subsequent runs, but he just took a tremendous length of time and was all tired out after the cleaning out job, and, therefore, we later assigned two or three men to that, and we didn't feel particularly perturbed about the test because many things happened during that test.

In running the acid out of the crock, and coming down into the tubes, we left a vent there that would extend up above the level of the acid in the crock, so that any hydrogen generated or liberated by the attack of acid on the tubing would bubble back up and come out of this glass tube, and what happened was that it was like a fountain, that the bubbles would come back and the acid would squirt up into the air, and it scattered over the equipment, and I don't know how many gallons of acid were lost in the test, pos-

Dr. Carl F. Prutton

sibly one or two, but it made kind of a mess. So we had to modify the equipment in that respect.

The other differences in Run A were the shape of the tubing. There was one welded fitting which made two of the pieces of pipe welded together, which we never used in any other run later on, and we used—we numbered each tube we purchased, and we used tubes 1 to 5 to run A and we never used those tubes again in any other subsequent runs.

Q. Will you identify that run with the five runs that you have outlined in your program? A. That run was supposed to be a blank run, or a run of raw commercial acid through the tubing.

Q. And what letter was given to that run when it was made? A. In our data book, it was given the letter A, first run.

Q. Can you show to the court the set-up of the tubing used in that run? A. Yes. If I may have that preliminary report? It was not included in any subsequent reports.

(A volume was handed to the witness.)

Q. Will you just explain how that set-up differed from the one that was later adopted and used in all of the tests referred to in your report, in your final report? A. This had four lengths of straight tubing, and subsequently we used five lengths of straight tubing—is that correct, Mr. Lightfoot?

Mr. Lightfoot: Yes. A. But we had this peculiar bent piece of tubing here, (indicating), which we hooked up. Oh, we did not use that tubing for any further work. We then went to this set-up which involved the lengths of tubing and this long length of tee here (indicating). We could use that with Menaul test tanks as well as the other types of tests which we ran directly from the stoneware crock (indicating). This is glass tubing down around this here (indicating). There is a rubber stopper connected on to that (indicating). This elbow at right angles was used in subsequent tests.

Mr. Lyon: I think this had better be marked, the first one that you referred to, as PX-229.

Dr. Carl F. Prutton

Mr. Owen: And the second one as PX-230.

(The figures above referred to were then marked PX-229 and PX-230.)

Q. I am going to remove these from the preliminary report. Now, Doctor, this set-up that is shown in the second of these figures, which is PX-230, was that used in any of these first five runs? A. That was used in all subsequent runs that we made.

Q. That is, in all those that you made from the stone-ware crock? A. Yes. Should I go on with the description of this?

Q. Of that run A. I want you to tell all about that run A, which is not included in your final report—that is true, is it not? A. Yes.

Q. I want you to tell all the reasons why you did not include it in your final report? A. The analysis of the samples of acid entering the tubing system and leaving the tubing system, were turned over to one of my assistants—I believe it was Mr. Riehl—was it not?

Mr. Lightfoot: Yes. A. And without any great specific instructions as to how to make these determinations. And we had in the same laboratory, right opposite his office, a graduate student who was using the orthophenanthroline or colorimetric method for determining acid in low concentrations. And this man Riehl took these samples and ran them by the orthophenanthroline method. I think some of the samples in one or two of the other runs were run by that method. But when we finally adopted our standard method of volumetric procedure, we did not go back and run any of the runs of run A, because we thought that it was not worth while, and I will explain further along that line.

Another factor that entered into the thing was the iron content of the effluent acid showed a great falling off during the run which wasn't particularly noticed to any great degree in the subsequent runs with raw acid. And I would like to give you those figures. Do you have that run A Mr. Lightfoot, to show the falling off in iron content?

Dr. Carl F. Prutton

(Mr. Lightfoot produced document.)

The iron content ran from 1.055 milligrams of iron per c.c. It went up to 1.15 after the first sample was taken, then started on down to 1.075 but the last composite sample taken was .525—more than a 50% falling off in the iron content. Now in later blank runs that we made, that is, using the raw acid through the tubing, we had changes, as we mentioned heretofore, but they were not of that order of 50%. They were a slight change. For example, the first composite sample in run 1A blank 1350 parts per million of iron, the second composite 1450, and the third 1405. That is a variation of about 25% maximum variation in the composite samples analyzed, and we had over 50% in that one which indicated that something had happened. I don't know what.

Q. With that colorimetric method of analysis, what did you find out about it in connection with these tests? A. I knew all along it was to be adopted only for small amounts. The man who did the work, evidently the student was using orthophenanthroline and he picked it up and used it. It is supposed to be used for minute concentrations of iron.

Q. It was not appropriate for this use? A. Not appropriate for this particular run. Now, we did run later on the gravimetric determination and one or two samples from 1A and they checked within about 10% of the figures that had been obtained from the phenanthroline method, but evidently the method isn't too accurate for great amounts of iron. These were very high concentrations.

Q. And then you adopted what? A. And then I talked to the man and took him off this colorimetric method and put him on the gravimetric method. That worked all right until we got to the high lead concentrations, but it worked very well for blank runs.

Q. And then when you discovered that the gravimetric method was not suitable for analysis of acids containing lead and iron, you dropped that and went to the volumetric method for all? A. We ran back all the valid

Dr. Carl F. Prutton

samples. We got all the samples from the valid runs and repeated the analysis on all of them by the accurate method.

Mr. Lyon: Just one moment. I was looking for that original book that we had yesterday, that had all of this data in it. A. Mr. Lightfoot, do you have that?

Mr. Lightfoot: Yes. A. Open it up to the page where the data is.

Mr. Owen: When you purchased these thirty sections of oil well tubing did you mark them in any way so as to identify them? A. We marked at least 28 lengths of tubing with a definite number that was kept on that tubing from then on.

Q. What were those numbers? A. From 1 to 28.

The Court: You described two or three methods? A. We described three methods.

Mr. Owen: Which ones of those sections were used in this set of tubing in which you ran your first run, A? A. In run A we used tubes 1 to 5.

Q. Were they ever used again? A. No.

Q. What became of them? A. Well, we started out on the premise that we were going to use one set of tubes for each run, because we thought they were all uniform, and after we had run five tests and consumed all of our tubes we found that they weren't uniform, and came definitely to the conclusion that we couldn't run different tests on different sets of tubing, we had to run different tests on a similar set of tubing, and ~~any~~ comparisons—

Q. (Interposing): You had to run comparative tests on the same set of tubing? A. After giving them a standardized cleaning procedure, which eliminated and presented a new surface inside.

Q. Were any of these first five sections of tubing used in your smaller tests, your laboratory tests? A. As I recall it, several of those lengths were cut up into the corrosion test specimens that we used for later work.

Q. Now, I call your attention to Figure 2 in PX-184, which was identified as PX-174-A, and will ask you to compare that with the last exhibit, PX-230, and point out any

Dr. Carl F. Prutton

differences between the PX-230 and PX-174-A, both of which show your set-up using the stoneware crock. A. I would like that other figure.

The Court: Here. Is this it? A. These figures are identical as regard the set-up. Starting at "Y" is the steel tubing elbow that we made up with the long side arms on it, welded together, and starting at "Y"—

The Court: You are comparing PX-174-A with PX-230, and not with 229? A. That is correct. This long elbow,—it really was a "T," because at one side, extending down here, we had a rubber stopper in there, and that section form was used in all of these crock runs. Down below here, the end of the straight lengths of tubing, there was a rubber stopper inserted, and I have described that, that had this 1-inch Pyrex tube.

Q. That is in 230? A. Yes, which led out of the end of the tube, past the screw clamp, and into this metering bottle, and we could adjust the flow by means of that screw clamp, and the height of the acid in the bottle indicated the rate.

The Court: What was the object of putting these joints in and not having it to go straight down as it was in the well? A. This set-up has a height of 12 or 13 feet from the top to the bottom, and a total length of one hundred twenty some feet, and we had to take the laboratory, we had to work it around through a door from one lab over to another, and it had to go around a corner.

Mr. Lyon: You could look at this drawing, and the beginning of this was at the top and the other at the bottom and it flowed vertically, but as a matter of fact there was a little incline? A. Slight incline. It was about six feet in a hundred.

The Court: It is all more horizontal than it is perpendicular, I remember that. A. Yes, but these PX-174-A and PX-230 show identically the same system of tubing arrangement and set up used in the run E, which was our fifth run, and the later runs with the raw acid directly from the crock through the tubing system.

Dr. Carl F. Prutton

Q. Well, using any acids? A. Yes.

Q. Either raw acids or synthetic acids? A. Or synthetic acid from the crock through the tubing system.

The Court: Now, why do you tell me that the apparatus as it was in 229 was any different in result, why would it be any different? A. It would differ but slightly in that this was a short length, it was shorter in length than that, and it was bent around at that angle. We did not have a "T," but this peculiar bend.

The Court: What difference would it make? A. It would make a slightly lower amount of iron dissolved because it is shorter tubing length, and the other difference—

The Court (interposing): But the bend, would that make any difference? A. It wouldn't make a great deal of difference, only that there is a little difference in construction. This tube, which was glass, at the start of the run was open, and that is where the slugs of gas would come up, the hydrogen and slugs of acid would squirt up in the air. So shortly after the run was started and they had acid spilled all around, they connected a rubber tube to the glass tube to get it back into the tank, to prevent it slopping.

The Court: The real reason as to whether or not the bends would make a difference or not, you do say it would make—might make a slight difference— A. (Interposing): Slight difference; not a major difference.

The Court: I would say so far as there are any bends in it, it is different than a well construction. You see the thought I had in mind, Doctor. A. It wouldn't make any great difference.

The Court: All right. I think right there I will ask you, the slight difference, which way would the difference be, the bend, that it would make more corrosion or less corrosion. A. This is an opinion. It would be my opinion that corrosion is increased with greater turbulence, and a right angle bend produces more turbulence than a gradual bend, so you would get slightly greater corrosion with that right angle bend than you would with a bend that came across at 45 degrees, but it wouldn't be a major factor.

Dr. Carl F. Prutton

In other words, if you pass water around a corner in a pipe or elbow, that water tries to go straight ahead, and it churns up on itself, and if you had acid in the steel pipe that churned up, or turbulence at the bend, it would tend to attack the steel and wipe off that coating.

The Court: It would at one place. I am thinking of the creek and the effort it makes to go straight ahead as it makes a curve, wherever there is a bend it has a tendency to go straight ahead. A. Go ahead.

The Court: Straighten it. We find a greater corrosion at one place, and we find sediment and lack of corrosion at another place. A. This doesn't form sediment, because it forms soluble iron chloride that stays in solution. I don't think it is a major factor.

Mr. Owen: What was the rate of flow through the pipe in these tests? A. The rate of flow, that is the first time we used this rate of flow control, and it varied considerably during the run. We had never adjusted the rate of flow controller before, so it was—there was considerable variation in the rate of flow during the test.

Q. During all the other tests that are in your final reports, the rate of flow was what? A. That was adjusted at one gallon per minute, and we attempted to adjust this first one to one gallon per minute, but the operators were not as skilled as they became later on.

The Court: By the first one, you mean Run A? A. Run A, which was not reported.

The Court: And that is one run? A. Yes.

The Court: Well, when we come to the final results, you ran more than one, didn't you? A. Oh, we ran eighteen total runs.

The Court: But with each pipe—five each, I thought. A. Five or six with the same tubing, with the same number tubing.

The Court: But with this first tubing you only ran one? A. Ran one.

The Court: Discarded that? A. Discarded the tubing. Because we figured we were going to do that in the beginning.

Dr. Carl F. Prutton

Q. Now, the next one, which you originally marked B, followed the one that you have just described, is that right? A. That is correct.

The Court: In other words, the one he has just described was used with— A. (Interrupting): Raw acid from the crock.

The Court: I wanted to get that number.

Mr. Owen: No. 229, run A was used on that. A. Oh, yes, run A.

The Court: And B was PX-231. Is that right? A. Yes.

Mr. Owen: In the subsequent runs he used PX-230.

The Court: PX-229 was the one that did not have the right angle corner—is that correct? A. That is correct, yes.

The Court: And the one with the right angle corner is PX-230? A. Yes.

Mr. Owen: Will you explain that second run? A. The second run, or run B, was a test in which we took our polarized Menaul tank and connected it to the tubing system, and then at a higher level with it, this stoneware crock, and in the stoneware crock we diluted commercial acid about 15 per cent concentration; and then we tried to run that into the tank, the Menaul tank, and immediately run it through the tubing, with the idea that—

The Court (interrupting): Oh, I remember that one, and you got an average rate of an hour and a half. A. In that tank, and we picked up quite a bit of lead, and we got some inhibition.

The Court: You figured that was about an hour and a half, but it was not definite? A. Yes.

The Court: But it was not definite? A. No, it was not definite.

The Court: It wasn't three hours, and it wasn't any hours? A. No.

The Court: You tried to get a test without staying in there at all—. A. So that there would be no lead or copper picked up from that tank.

Dr. Carl F. Prutton

The Court: You figure what you actually did was to get an average of about an hour and a half in that tank?

A. About an hour and a half in that tank, and we got about one and a half parts per million of copper, and about half as much lead as copper, and we got about half as much inhibition; but the thing we did wrong in this particular test, due to our ignorance, we thought the tank would not corrode very much, but we took only two samples out of that Menaul tank—we filled it up with acid and immediately started running out of the Menaul tank into the tubing, and we took a sample at the beginning, and one about half-way through, just two samples, to try to give us a figure as to the iron content. We thought it would stay fairly low, and when we got through, we found even with two samples, instead of being saved separately, they were blended together to make a composite, and that composite showed 457 parts of iron, or some value like that, about a third as much as was found in the Menaul tank acid later on, indicating—is that correct?

Mr. Lightfoot: Yes.

A. The commercial acid when diluted has only contained five or ten parts per million of iron, and, therefore, after the acid got into the tank, the first sample was probably close to five or ten. The other sample taken half way through the run, when it was blended in equal proportions with the first sample, showed four hundred and some parts per million of iron, indicating that it was a tremendously high concentration of iron.

Now, we did not want to use any figures of iron content where it was changing rapidly, based upon a composite of two samples. We did not think that was an accurate way of doing things. And also, the test indicated that it was impossible for us to do the thing we started out to do which was to separate the electrical effect of Menaul from the chemical inhibition effect. In other words, we ran a Menaul test with the wires connected (that is the next test) duplicating Menaul process, and we figured we would get electrolytic protection by the Menaul method, if any, plus the

Dr. Carl F. Prutton

chemical inhibition effect. Then if we run this acid through so rapidly we would just get the electrical effect and we could measure the proportion of each.

Mr. Owen: That is, you wanted to get the effect of the acid as it existed in the Menaul tank after 6½ hours being stirred periodically, and didn't want it to take up any more lead, copper or iron before it ran through the pipe? A. No, we wanted to run a Menaul test putting the acid in the Menaul tank and agitating it for six hours to get metals picked into it, and then run it through our tubing system. Now, we felt that in that test the protection of the tubing from the acid would be caused by two separate effects. First, any metallic inhibitors; second, the electrical effect claimed in the Menaul patent. So that is a combination of the two effects. And then this separate test, which was run as test B, was to try to separate the electrical effect completely from the chemical inhibition effect. It did not succeed because we got inhibitors in that acid during that rapid pass through. The rate of attack of the acid upon that Menaul tank was so great we didn't take enough samples in order to accurately indicate how much iron was in the acid when it entered the tubing, so we could figure the difference across the whole run.

The Court: Wasn't there any way to let your commercial acid run into your pipe without going through your Menaul tank? A. Yes, and we did that in later tests. But we wanted to give them the benefit of the doubt of having actually a lead electrode connected in there. To give them the benefit of the doubt to get a lead electrode connected in there, and we couldn't run it by the lead electrode in the steel tank fast enough so it would not pick up lead and copper from the tank.

The Court: Have you yet devised a way so you can separate and say how much is due to the inhibition in the acid no matter how they claim it, the inhibitors in the acid? Is it the sort of a problem you can't unscramble? A. No, we did solve that. In other words here we measured a combination of two effects. To do a real complete job you

Dr. Carl F. Prutton

would measure each job separately and see if they measured up to the total sum of the two.

The Court: How are you going to measure them separately? A. I will come to that. This attempt we made here was to get the electrical effect separate, and it didn't work.

The Court: I see. A. Now, to measure the chemical separately, we prepared the acid in the stoneware crock with added chemicals and ran it through the tubing and duplicated the composition.

The Court: Did you let it keep on working while you were using it? A. This is a later test.

Mr. Owen: This was in the stoneware crock. A. In the second test we tried to get the electrical effect and could not get it, but the fifth test we ran was a test in which we measured the chemical part alone and the chemical part was equal to the total of the two, see.

The Court: You measured the chemical part in what way? How did you get that? A. By simply preparing this acid with the same concentration of added metals as the acid had in the Menaul process, leaving the Menaul process, going to the tubing and we didn't put the electrode in. When the chemical inhibition leaving from the stoneware crock, going directly to the tube, and the inhibitor gave us the same result as the total of the two, we figured the electrical effect was zero. If it hadn't been zero we would have been quite puzzled as to how to proceed.

Q. And in that run you have just described, and which was identified as run B, you used the equipment as shown in Figure 5 on page 17 of PX-185? A. Yes, that is correct.

Mr. Owen: I think Your Honor saw that. The stoneware crock is above. The acid was put in the stoneware crock and then run down from that crock into the Menaul tank.

The Court: Is that different from PX-230? A. That was the Menaul tank.

The Court: Oh, yes.

Dr. Carl F. Prutton

Mr. Owen: And 230 doesn't have a Menaul tank.

The Court: That is right.

Mr. Owen: Now, your run B is one of the runs that was not incorporated in your final reports? A. That is correct.

Q. Now, proceed and explain your third run, which was identified as run C. A. Run C is reported in the report as 1-N.

Q. That is in PX-185? A. As run 1-N, and we used in that run tubing numbers 12 to 17.

Q. Oh, I did not ask you, Doctor, what sections of tubing you used in that run B? A. In the run B we used tubing numbers 6 to 11.

Q. Were they used again? A. They were not used again.

Q. Your third run, C? A. Was 12 to 17, and those were run—and those were designated as Series 1 tubing in this test.

Q. And so referred to throughout your report? A. Yes. In this test, this test was a Menaul test, and to just give you the brief elements of it, it is reported in the report. The acid was prepared in the stoneware crock, diluted to fifteen per cent, checked for analysis and inhibition, and then run into the Menaul tank and agitated for about six hours with this periodic agitation, to duplicate or give some manner of equivalent action to the rattling of the truck over the roads, the shaking that it would get.

The Court: When you say that acid was checked, you mean you checked it chemically? A. And by running the inhibition on the third laboratory specimen, or, rather, the little laboratory specimen. We ran both the chemical analyses, and it showed a very low copper and lead content and the inhibition ran from zero to 6½ per cent, of all the acids used.

The Court: What are you comparing that to? A. That is just a small laboratory test.

The Court: Well, I know, but six per cent of what? A. Six per cent reduction. I would like to go into that very thoroughly just a little later.

Dr. Carl F. Prutton

The Court: But one reason we haven't any standard way, we not only haven't any standard here to go back to the old thing about the conditions, but we haven't any standard as to where we start, either, have we? A. We have a standard—

The Court (interposing): You can fix one, I mean, but another fellow will take another standard. When we take one hundred per cent, nobody knows what that means until they tell. There isn't any standard here, as a starting point, as to percentage of inhibition and percentage— A. (interposing): The starting point is the rate of attack of C. P. hydrochloric acid.

The Court: You have got to go on and tell me under what conditions. A. I know that.

The Court: So there isn't any one hundred per cent.

Mr. Owen: We had to make our own standard.

The Court: Sure. I didn't want to emphasize the corrosion thought I had.

A. In this test, and that has been completely reported and discussed in detail—

Q. Yes. I don't want you to go into that again, Doctor.

The Court: When you found one hundred per cent or six per cent, was that the figure you used, six per cent? A. All of the acid we used, our commercial acid, diluted to fifteen per cent, shows values of zero to $6\frac{1}{2}$ per cent, if I may use the term, inhibition.

The Court: What I want to get at, what did you take as the six per cent of what? A. We took a single piece of steel and tubing and put it in a certain volume of acid.

The Court: Pure hydrochloric acid. A. Fifteen per cent C. P. acid.

The Court: And under the same conditions you put the commercial in. A. That is right, and the rate of attack was within six per cent of the C. P. acid.

The Court: All conditions were exactly alike. A. That is correct.

Dr. Carl F. Prutton

The Court: Except that one of them was HCl. A. C. P. pure.

The Court: Pure, and the other was whatever you had. A. Commercial acid in that tank.

The Court: All right. Now, I have got it. A. Now, the next run, run D was run—I might mention in this run C—

Mr. Owen (interposing): Your run C that you have just referred to is run 1-M in Table 9 of PX-185? A. That is correct.

Q. Now, will you describe your next run, run D? A. Well, run C, as I mentioned—this is going back to C—is the Menaul tank in which we connected a wire between the tank and the tubing as taught in the Menaul patent. Run D is numbered 2-N and is reported in the report and used.

Q. In report PX-185? A. 185. We used tubings numbered 18 to 23 in that particular run. The number of the tubes were 18, 19, 20, 21, 22 and 23.

Q. And that became your Series 2 tubing? A. That became Series 2 tubing. In that test 2-N we did not connect the wire in the Menaul process. We did not connect the wire. That was the only difference between run 1-M and 2-N. The "M" means Menaul, and the "N" means "No wire."

The Court: That is, no wires connected? A. So we had four runs that we completed at that time, and we went back to run B, that is the quick Menaul test, to see if we could not do it the second time. We hadn't got complete enough data to calculate it the first time.

The Court: Is that run B? A. Run B, so the 2-B was the check on B, and we used tubes No. 24 to 28, on that particular run.

Q. Were those tubes used on any other run? A. They were not used on any other runs.

Q. Well, now, explain very briefly this run 2-B. A. On run 2-B we had all of the iron data, and the inlet acid—

The Court: Could we call that "D"? A. That was not even reported.

Dr. Carl F. Prutton

Mr. Owen: It is 2-B.

The Court: It wasn't reported? A. It wasn't reported. It isn't in here (indicating).

The Court: I have got A and B, and they are not reported in here, so that doesn't seem to be a reason for eliminating this. A. A and B were not reported at any time. In test 2-B we got the data, the correct number of inlet samples at different times to run the iron on and other metals. We also got the exit samples sufficiently enough to calculate the amount of iron that was picked up in going from the end of the tubing in the Menaul tank over to the exit; but the samples showed a considerable amount of lead and copper, just as we had obtained before, and the amount of iron that dissolved was somewhat less than the amount that was dissolved in run A, in which we had just put the raw acid through.

In other words, we got about the effect that we expected after run B, that if these metals were in there, in checking run B and running it into the tank and taking it out as fast as we could, that metals were picked up which gave it some inhibition in going through the tubing, but it did not determine the thing we were after.

The thing that we were after was to get a clear cut separation of the metallic inhibition from the electrical inhibition. It did not give us the electrical effect alone, and therefore we discarded both of those runs.

Mr. Owen: Now, you have made five runs, and you have discarded A, B and 2-B; is that right? A. That is correct.

Q. Now, will you go on and describe run E, please?

A. Now, Run E, at about that time we came to a definite conclusion that we had to, if possible, use, select certain tubes and run the whole series of runs through those same tubes, giving them a standard cleaning out in between each run. That apparently we could not check between runs made on one tubing system under one condition and runs on another.

We had losses of weight, for example, in all of these

runs, we had losses of weight in each piece and each fitting in each of these runs, and they would show variations of 20 per cent, and, therefore, we wanted to use the same tubing and run a whole series of comparative runs through the same tubing system, and so after the first five tests we looked over the data and we picked out two sets of tubing so we would get a check on a series run on one set of tubing and a series run on a completely different set of tubing.

We picked out two sets of tubing that had been run in two of the valid runs that we had made. Now, there were only two good runs out of the first five, because in run A we had this trouble of the varying of many conditions, and the blank, we didn't think that was very good, and, as I recall, at the time when we completed the five tests some of those lengths of tubing had been cut up to make corrosion samples, and so we couldn't run that one or didn't think it desirable.

Run B gave us this indeterminate result that would not clearly separate the electrical effect from the chemical inhibition. 2-B was the same. But runs C and D we felt were valid runs. So we picked the tubes out in those two runs, and decided that we would run, in different order, this sequence of tests that we had outlined.

We eliminated this quick Menaul method, however, in subsequent work. We decided we couldn't do that, because we had tried it twice and failed, and, therefore, we started to run a series of runs using the No. 1 Series tubing.

The Court: 12 to 17.

A. 12 to 17 is the Series 1 tubing. And that had been used in the Menaul test which we had used the standard—

The Court (interposing): You had to renumber it in order to make it Series 1. A. That is right, change the letter designation.

The Court: Yes. But— I see, all right. A. Yes. And then 2-N which was reported, which was a no-wire Menaul test, we figured was a valid test, and the tubing used in that was 18 to 23, and we just called it Series 2 tubing, and that is the reason—

Dr. Carl F. Prutton

The Court (interposing): 18 to 23, inclusive. A. 18 to 23 is correct. So we did not try any of these quick Menauls any more. We started in our series of running the tests as outlined, dropping out the quick Menaul test.

Q. Explain now your next run, which is Run E. A. Run E was a blank or a raw acid run from the crock, using No. 1 series of tubing.

Q. And that is Run 1-AA in PX-184, is it not? A. That is correct.

Q. That is your Table II? A. That is correct.

The Court: What do you call that? A. 1AA.

Mr. Owen: Now, you explained at the outset, Doctor, that you planned to run five different runs and you have now explained six runs. A, B, C, D, E and 2B. Now, I will ask you regarding your Run 2B, the other 5 runs corresponded with your original plan.

The Court: Let's see about that. Before you start to talk about A. He has 5 runs, discarded 3 of them and saved 2.

Mr. Owen: That is right.

The Court: All right. Now he is starting in to run a series of 6 runs with 2 he has saved out of the 5.

Mr. Owen: And what I want to bring out now is that Run E corresponds with the first of his original plan. A. Yes, sir.

Q. Which was discarded? A. Which was raw acid. We didn't feel it was a satisfactory one and we didn't have Tube 5 to keep a sequence with. We had the four of the originals but we did not have the fifth section.

Q. Then we are down to the point where you adopted these two series, 1 and 2, for all runs? A. Yes.

The Court: And you are going to use the one you used in C for Series 1, and the one you used in D for Series 2?

Mr. Owen: That is right.

Mr. Owen: Well, we have gotten down to your run E as originally marked, and which became run 1-AA in your report, Exhibit PX-184. Now, take up very briefly run F and state what that was and what it became in your re-

Dr. Carl F. Prutton

ports. A. May I at this time put in the explanation of that preliminary report?

Q. Yes. A. At the completion of run E a preliminary report was written to be sent to Midland to give an idea as to how this work was coming, and Mr. Lyon has read from some of the conclusions of that progress report, conclusions that were diametrically opposed to what I contended at the completion of the work, and the first thing I would like to do would be to read all of the conclusions, instead of just the one, and then to explain just the picture as it existed at that time. I have here this progress report dated March 1, 1940, and at this time we had completed, and as reported here, all of the runs through E.

The Court: What is the date of this report? A. March 1, 1940, and the heading of the—

The Court: Just wait. As I understand it, this is your report made at the conclusion of the five runs up to E? A. That is correct. There were six runs.

The Court: And you want that called preliminary report, March 1, 1940, at conclusion of experiment E? A. That is correct. And the report is titled "Progress report on Menaul tank," and the heading at the end is headed "General comments."

The Court: All right. A. First, the rate of attack of hydrochloric acid—

The Court: Are you going to read the entire report you say? A. No, just the comments. Mr. Lyon read one of the comments, and I would like to read them all.

The Court: All right. A. (Reading): "The rate of attack of hydrochloric acid on various lengths of tubing seems to vary considerable from length to length and be quite dependent upon the method of cleaning the metal surface.

"2nd, in duplicating the Menaul procedure the amount of inhibition exhibited was much greater than would be indicated by the chemical inhibition shown by the entering acid."

Dr. Carl F. Pruiton

Now, that is the statement that he wanted me to explain. In duplicating the Menaul—

The Court: Read that again. A. "In duplicating the Menaul procedure the amount of inhibition exhibited was much greater than would be indicated by the chemical inhibition shown by the entering acid."

The Court: Which leads to the conclusion, just standing right there, that what had been done in the tank increased inhibition, is that right? A. That is correct. That is what one would get if they read that statement alone. I will go ahead with these comments and come back to "Two."

"Third, when the wire was disconnected in the Menaul method even greater inhibition was obtained," which is a conclusion that we have recorded.

The Court: Read that again. A. "When the wire was disconnected even greater inhibition was obtained."

The Court: Yes. A. "Fourth, potential and current measurements cannot be reasonably interpreted.

"Fifth, loss of weight of iron from tubes determined by direct weighing, which was the loss in weight of iron in Menaul tank, may be completely explained on the basis of chemical inhibition."

I am somewhat at a loss as to that particular comment. We have felt that the analytical determination of iron in solution to be a more accurate method than is implied in the loss in weight method from the tubes, and we use the analytical procedure.

"Sixth, we are completing a run in which acid, duplicating in chemical composition that obtained in the Menaul storage tank in run C will be run directly from the stone-ware crock to the tubing, the same tubing used in run C, 2-B and E will be used."

That is the sequence of the tubing.

The Court: Well, that sounds like you are telling what is going to be done in what you had in E, rather than—A. (Interrupting): No, in E we ran simply the raw acid for one set of tubing. We are telling him what we are

Dr. Carl F. Prutton

going to do in the synthetic run. At the time of writing this report we had no synthetic run. All we had to go on was the comparison of the reduction in corrosion in this Menaul tank.

The Court: That you rigged up? A. Yes, and the raw acid, and we found that there was 75 per cent reduction in corrosion, whether we had the wire connected, or not, over what we got with the raw acid; but on the acid that we fed into the system, the acid that went into this pipe in the Menaul tank,—we had taken samples of that and tested it in the laboratory for the amount of inhibition, simply by putting it in this beaker with a small volume of acid, and allowing it to stand, and comparing how much it had reduced the attack of the acid, that is, the metals that we put into the Menaul tank, so we were comparing the reduction in attack in a large system with the reduction in attack in this small specimen test. And the small specimen test that we used at that time was this, we took a small section—I cannot give you the exact dimensions, but I could look them up, but in general it was about an inch by three-quarters, cut out from the side of a piece of oil well tubing, and about three-tenths to four-tenths of its area was this cut-out edge of the section of the sample.

The sample was cleaned and then immersed in a small volume of acid, and allowed to stand for thirty hours; and when we got through with that test we found that the acid that had been taken from this Menaul tank just before, and during the run, when it was running into the tubing, the acid with the lead and copper and iron it had picked up in the Menaul tank, that acid in this laboratory test had shown between 30 and 40 per cent reduction in corrosiveness only; and, therefore, when comparing in this report with the only data we had,—we had not completed a single large scale synthetic run, we were comparing results on our laboratory inhibition tests with the results of this large scale test, and we have gotten 75 per cent, or plus or minus 10, reduction in the large scale equipment, we have shown that the wire made no appreciable difference in the results,

Dr. Carl F. Prutton

which also would tend to indicate that there was no—quite definitely that there was no electrical protection, and we got 30 to 40 per cent inhibition on the acid in this laboratory test, and 75 per cent on the large scale test, and, therefore, the only comparison that we could have made now was the comparison of those two figures, and, by the way, it seemed—it simply appeared as though maybe there was something there from that particular comparison.

Now, following this particular progress report, and as indicated in here that we were going to run this synthetic run, which would really answer the thing, because we would have two large scale tests to compare following that run—the run E, we then went to run F, or run 1-B, which was the first synthetic run that we had made, and the date on which we had that run was March 17, 1940. This report was dated March 1, 1940. The first synthetic run that we made was run 1-B.

Q. And that run, as I understand it, was run from the crock? A. Directly into the tubing.

Q. In which you placed 15 per cent commercial hydrochloric acid, and added to it the metals corresponding in amounts to those found in your Menaul run? A. To those found in the Menaul run, 1-M. And we found that with the synthetic acid we got 238 grams of iron dissolved from the tubing, and with the Menaul run 322 grams of iron dissolved. The synthetic from these figures would appear somewhat better but it was at least as good.

Q. Then, Doctor, you go on through your subsequent runs down to Run I and explain them quickly. A. The next run was Run 1A or G in our data book—G or 1A. Now, the purpose of running that particular run and in the order that we had run it was this: We had in Run E run raw acid through the tubing. After that raw acid run we had given the tubing a thorough cleaning out with our standard cleaning procedure and we ran run 1B, the synthetic run. Then we came back and ran a raw acid again to see if the cleaning out procedure we used would take any metallic coating off the inside of the tube and

Dr. Carl F. Prutton

give us a fresh surface that would be comparable with the fresh surface of the pipe prepared before acid containing the inhibitor had been run through.

Q. This is 1A? A. 1A is our report and G is the letter in the book.

Q. Raw acid again? A. Yes, sir. We found in the first we got 943 grams, the second 1043. We considered that was probably the limits of accuracy of the metal but at least we had gotten a fairly close check on the attack of commercial inhibited acid or diluted acid to 15% strength upon the tubing.

Then Run H, which is run 2M which is reported, was run on Series 2 tubing. Now, we had only previously run 2N or D on that set of tubing so that we had a Menaul method following the Menaul without the wire. The first test made on the series 2 tubing was the Menaul minus the wire. Then we ran a Menaul with the wire in the same tubing after, of course, cleaning it out as described. Then—

The Court: What about the wire? A. The wire was connected. That was the Menaul procedure. And then Run I was to have been a synthetic run and it was run upon series 2 tubing, and it was supposed to have contained after we had added the chemicals to it, the same concentrations of lead, copper and iron that were present in the run 2M.

Q. That is the last one you referred to? A. Yes. Now, that is the one run after we started on this 2 series of tubing system that has been dropped out of the report, and I want to explain that.

The Court: This is I and what is the other letter? A. There is no other letter because it wasn't used in the report. In Run I we calculated the amount of copper salt to be added and the addition was supposed to have brought the total concentration up to about 2.8 parts per million of copper. The number that is written in our data book of added copper salt would correspond to about $2\frac{1}{2}$ parts per million and there was around .3 of a part per million in the original acid, which would theoretically make everything correct.

Dr. Carl F. Prutton

Now, we ran tests after the acid was blended, the chemicals added. We ran this small scale inhibition test upon a sample of that acid before it went into the tubing. The percentage inhibition shown in that test instead of being around 30 to 40, which was usually the case with synthetic Menaul type acids, as I recall it ran 16 or very close to 16, indicating about half or maybe a little over half of the inhibition that one would expect in an acid that contained 2.8 parts per million of copper. The analysis showed around 4 parts per million, and that is the analysis that I doubt seriously of the inlet acid, 4 parts per million, much more than we had actually added. The analysis of the exit samples—and we have three of those determinations in duplicate—all showed from 1.2 to 1.4 parts per million. The loss in weight of the tubing that we obtained was 469 grams of iron. From the tests that we had made and have made since then, that loss in iron would agree very closely to the loss that you would get with about 1.3 or 1.4 parts per million of copper. It would not agree with the 4.

The Court: This is the experiment that you and I finally reached the conclusion there were six elements to be considered and two of them must be wrong, and you thought the one most likely wrong was the one that—

(Witness, interposing): —had the least possibility. That is correct. That is the one test that we have dropped after we adopted this 2 series tubing. That is the only one. Now the other tests, in order, and without any great amount of discussion as we have gone over these, run J, or 2B was synthetic; then run K, which was a blank, 2A in our report, followed by L or 1N, which was a no wire test on the first set of tubing—that is the Menaul test without the wire, then followed by N, which was a synthetic on series 2 tubing and is listed as 2D in our report.

Q. Doctor, after you discarded run I, how soon did you run a duplicate of that test? A. We ran it as soon as possible.

Q. Which one was the duplicate? A. It was run J.

Q. The next run. A. Or 2-B was immediately fol-

Dr. Carl F. Prutton

lowing that, indicating that at that time that we thought there was something wrong, or else we would not have run a duplicate on that.

The Court: How many did you save all told out of all these tests? A. Out of the ones that we have reported without oil,—there are two oil tests,—those have been discarded, and they were not really run under controlled conditions, exactly controlled, because they were preliminary studies.

The Court: Out of the others? A. Out of the others there are 17 tests.

The Court: 16 tests, and 4 of them discarded. A. 4 of them discarded. Two of those discarded were those quick Menaul tests. One was the first test which we didn't have correct cleaning procedure, or other exact analysis procedure, and there were a number of factors wrong there, and then the one, which I will admit is argumentative and debatable is run I.

The Court: It turns out there is just one-fourth of the tests that were discarded? A. That is correct.

The Court: And two oil tests, we aren't counting, that were discarded? A. That is right.

Mr. Owen: Now, Doctor, referring to the copy of your letter of January 28, 1941, to Mr. Rebbeck, in which you made some curves showing the rate of corrosion of the uninhibited 15 per cent acid and of the Menaul acid, that is, from the Menaul tank, can you, or have you the figures from which these crude curves were made? A. Well, following the writing of that letter we ran additional tests, and the data is in this book and could be presented in graphical form, and I don't think I could pick it out of here and calculate it. It would take some little time, and I think it would show up much better in graphical form.

Q. I would like to have you do that, and how long would it take? A. Well, it might take an hour or longer.

Q. I would like to have that done and when done I will offer it in evidence? A. You don't want me to do it right now?

Dr. Carl F. Prutton

Q. No, wait until you get off the witness stand, and if you possibly can do it so that we can get it in today, so that if counsel wants to cross examine on the basis of it in your notebook you will be here to explain it. Now, you testified that you made tests in accordance with Figure 1 of the Menaul patent and that your results were in general, or generally corresponded with those produced by Mr. Gardner in his affidavit? A. Before we go on to that should I explain those two laboratory tests that we have used for measuring this rate of attack?

Q. Yes. A. I mean that fit in with the picture of these large scale tests, and it is one of those things that I think should be thoroughly understood, and we have mentioned that we used two tests. I mentioned to you at the time of writing this preliminary report that we had used this sample test and run it for a very long period of time, and then the thing after we had run the synthetic run, then we had the problem that the big scale test showed 75 per cent, and the small scale test showed 30 per cent inhibition or so, and to try to find the factors that entered into that we studied the determination in a laboratory way of getting a laboratory test that would duplicate as close as possible the conditions in this large scale equipment.

Now, one thing that we wanted to show with that was that if we took chemically pure acid and added these chemicals to it, that there wasn't some unknown element, X, or something in there that was doing some sort of maneuvering that gave us that large scale result. And further we studied first the surface condition of the samples.

We decided that if we wanted a test that would compare with our large scale test that we ought to use the same method of calculating the samples, and that we shouldn't disturb a great proportion of area of the surface by cutting it with a hack saw, or some method like that, and so we went to a larger specimen and we used a 1-inch length of this 1¼-inch tubing.

We used a 1-inch length of this 1¼-inch tubing. We faced the ends off in a lathe, and got a smooth finish on

Dr. Carl F. Prutton

the ends, and we finished the inside in the same manner that we finished the large pipe; and the outside we did as close—cleaned it as close as possible to the method used for cleaning the inside. We put it up against a hard wire burnishing wheel which would take the outside coating off, and make a burnished outer surface on the sample.

We pickled the sample before that operation, and washed it with solvent, and then gave it that operation, and then a final washing in solvent as is described in this report.

Then we used the same ratio of acid volume to area of the sample as existed in this large scale test, that is, a certain volume of acid, a certain area of attack, the time was kept the same, the temperature. The only thing that we could not quite reproduce was the agitation, we could not do that in a reproducible manner to let the acid through that small section.

Carrying out the test in that manner, we got results which did not quite agree with the figures that we—when the acid was run through the large tubing system, but it came up pretty close to it, and we thought from work that we had done that increased acid flow gave increased inhibition, or reduction of corrosion; and, therefore, it would be logical to expect possibly that there would be some difference in inhibition.

In this report that I mentioned—I do not recall the PX exhibit number—but the report on the corrosiveness of 15 per cent hydrochloric acid, in that we describe that test, and give the reduction in corrosiveness of various metal contents in C. P. 15 per cent HCl, by that test, and those figures are very comparative, and we used various proportions of copper, lead and iron covering the entire range of any compositions that we had obtained either from our Menaul test, or that had been reported to us by Mr. Rebbeck as having been found in the defendant's samples by Dr. Bartell.

And the figures were 60 to 70 per cent inhibition, close to that range. And we varied the copper. I think I have

Dr. Carl F. Prutton

described this before. We varied the copper from about two, a little over two to about four parts per million, the lead from around 200 to 500, and the iron from about 400 up to 1300 or 1400, and over that range of compositions the inhibiting action or the reduction in rate of attack was found to be around 60 or 70 per cent.

Now, in our large scale, we got from 65 to 80 per cent, approximately, and we felt that this difference could possibly be explained by the velocity. And then we ran this check of length of time of contact on the samples, and we found that the reduction in rate of corrosiveness was almost constant between about ten minutes and about fifteen hours or so, and it started to fall off at the end of that.

Q. That is the curve you are going to prepare? A. That is the curve I am going to prepare. And the confirmatory nature of that test, with the large scale test, which we duplicated as close as we could in the laboratory, that is, in the small scale laboratory test, indicated to us the validity of our large scale test, and so the two agreed, in our opinion. And so, on the basis of that, the conclusions that were reached, I have expressed already, that the acid containing from 2 to 4 parts per million of copper, and from several hundred parts per million to 500 parts per million of lead, and 500 to 400 to 1300 of iron, in the form of chloride, that that acid, under the conditions of these tests, and apparently from a study of the effect of some of the variables under quite a range of variables and time of contact, gave us an appreciable amount of inhibition or reduction in rate of attack of the acid upon steel oil well tubing.

Q. Now, I have a note here, Doctor, that your preliminary report of March 1st, 1940, in which you report on the first five runs, made no reference to your Run No. B which is one of the discarded runs. A. Yes. That B was never even calculated, because we knew we didn't have sufficient data on the entering acid.

Q. Now, in connection with the Gardner affidavit, you testified that you made some tests following the disclosure

Dr. Carl F. Prutton

of Figure 1 of the Menaul patent, and that you got low potentials similar to those referred to in the Gardner affidavit. A. We ran such tests in the laboratory, inserting a strip of steel and a strip of lead into hydrochloric acid of various concentrations contained in a beaker, similar to the sketch shown in the Menaul patent, and determined with a potentiometer the potential difference between the two strips of metal.

Q. And that compared favorably with Gardner? A. I would consider it a favorable comparison. I think we had quite a discussion about some differences there, but I think they are in substantial agreement.

Q. I want you to state whether the results of your—of those tests which you made in any way alters the views you have expressed regarding the effectiveness of the Menaul method in giving protection to the well tubing? A. It does not alter one particle the conclusion that I gave you or my opinion on that matter.

Q. The fact has been brought out in cross-examination that in your Menaul tests you grounded the lower end of the tubing instead of the upper end of the tubing, which would ordinarily be grounded in an oil well. How would the change in the point of grounding affect the amount of current passing down the tubing? A. Why, I have testified that the grounding of the tubing at any point along the tubing would be substantially identical because the tubing is a very high—has a very high conductivity, and it was brought out in cross-examination, I believe, that this tube was grounded through contact with the casing at the top, and which would indicate a difference between what we have carried out in our test and what occurs in a well. I do not believe that makes any difference.

Then it was brought out that possibly the current we measured was not all the current that passed in that circuit, that some of it may have gone into the ground, and the connecting of the ground to the bottom of the tubing would tend to make it easier for such a current to pass down and protect the tubing, and if there were going to be

Dr. Carl F. Prutton

any protection, why, it would be protected better along the tube and down to the bottom end by such a connection.

Q. Where did you measure the potential in your tests made in accordance with Menaul's figure 1? A. The potentials were measured directly between the side of the tank and the tubing, the end of the tubing system, which was dipped into the acid.

Q. And where did you measure your potentials in the Menaul tests? A. That is what I just described to you, in the Menaul tests I measured between the tank and the tubing.

Q. Oh, yes. I wish you would compare the potentials you found in your tests, corresponding to Figure 1 of the Menaul patent, and those you found in your tests using the 110 feet of pipe. A. I believe that I went into quite a thorough discussion of the voltages that I measured between the strip of lead and the strip of steel in this little beaker, and they were around one-tenth of a volt, if you recall. Gardner got eight one hundredths, and I got thirteen one hundredths as the top figure, and in between we criss-crossed, but they were substantially a tenth of a volt.

On cross-examination I was asked as to the exact number of these potentials, and I got down a certain way in reading voltages before I was stopped, or interrupted, or something. In run 1-M, the voltage that occurred between the tank and the tubing at the start of the run, when the tank had 40 inches of acid above the lead sheet in it, was 0.00 volts.

The Court: Above the bottom of the lead sheet? A. 40 inches above the top of the lead sheet, which we measured.

The Court: Oh, the top of the lead sheet? A. Yes. It was 0 volts. Then when there was only $34\frac{1}{8}$ inches of acid left in the tank, the voltage was .0012 volts. When there were $26\frac{1}{2}$ inches of acid left in the tank, there were .0018 volts. Then when the acid was $22\frac{5}{8}$ inches deep, about half of it had gone through then, there were .0039 volts. Then when the acid was $18\frac{5}{8}$ inches, when there was that much acid left in the tank, it was .0043 volts.

Dr. Carl F. Prutton

Then when there was $15\frac{1}{8}$ inches of acid left in the tank, there were .0081 volts. When there were $11\frac{1}{8}$ inches of the acid in the tank, the voltage was .0174. When there were 7 inches of acid in the tank, the value was .030 volts. When there were $3\frac{1}{4}$ inches left in the tank, the value was .064 volts.

Now, I have four runs, and they all show potentials and voltages of about that same order of magnitude; the voltage was practically zero, and as the acid ran down in the tank, the voltage started up toward the values that we got in the beakers, they started up towards those values. But it did not occur until there was just a layer of acid covering the lead sheet. Now, one of the principles of the Menaul hypothesis in the plating of this tube is that a large flow of current occurs and coats over this tubing to flow into the tubing and give it this polarization, and these figures clearly indicate that nothing like that occurs in the beginning.

Now, the voltage you get at the end is due to the fact that when you take a composite electrode, and an electrode that is four-fifths steel and one-fifth lead, and you measure the potential between that electrode and another electrode, you get sort of average voltage of lead and iron between what other electrodes you are measuring, and therefore since the acid in the tank is in contact largely with steel in the beginning, you get a voltage of steel to steel, which is substantially zero, and then toward the end when the acid has fallen down and is in contact with almost 99.5 per cent of lead surface, then the potential of that element is about the same as a sheet of pure lead measured against iron, which we found to be one-tenth of a volt in our beaker tests, but that still,—the explanation that I have given, or the opinion that I have given on the impossibility of this few hundredths of a volt, even in the last few inches of acid, in the test, of doing any protecting, the possibilities of that are—I do not believe exist, and these voltages, the change in voltages is exactly what you would expect and you cannot on the basis of those potentials give any credence to

Dr. Carl F. Prutton

the idea that there was a polarization due to a flow of current, and then the current stops and you have everything held free from corrosion.

RECROSS EXAMINATION

By Mr. Lyon:

Q. I have a few questions. Did you make any tests to determine the amount of copper and lead or iron that would be picked up by the acid if you put it in the Menaul tank, or the rate of corrosion in that tank of the acid if the plate was not bonded to the steel wall? A. No, we did not. We did make some preliminary calculations. We found so much corrosion there that we just wondered. We thought, and I still think that the lead sheet does protect the tank somewhat, and we tried to make some rough calculations that would indicate that it might protect it 30 or 40 per cent, but that could hardly be exactly. We have nothing to compare it with.

Q. You referred to that as a little bit or a slight amount the other day. What amount of protection did you have in mind? A. Well, I don't know from electrolytic protection. In these rough calculations we figured 30 or 40% electrolytic and then there is some chemical inhibition. Just what the total might be, it might be fairly high. We found a considerable amount of iron dissolved much more than the field samples showed. We had four times as much iron in our solution at the end of six hours with mild agitation as Rebbeck reported to me as being found in the field samples.

Q. Did you make any tests attempting to find out what the results would be if you could get a lead plate that contained no copper and were able to entirely exclude copper from the system? A. No, we did not.

Q. Would you have any idea as to what the results would be if the defendant's system, the Menaul system was operated just the way it was and by some means you were able to keep the copper out of the solution? A. I couldn't tell you that without running tests, I don't believe.

Dr. Carl F. Prutton

Q. You didn't run any? A. No, we did not run any tests whatsoever on that.

Q. This brush that you used as a burnishing brush for the tubing between tests, what was it made of? A. It was a hardened steel wire brush. Mr. Lightfoot, could you describe it better? What were the wires? They were round wires, cross section, and about how long? Was there any copper or anything on that brush?

Mr. Lightfoot: It is a brush commonly used for cleaning flues.

Q. That brush would scatch the inside of the tubing more or less, abrade the tubing. A. Somewhat.

Q. Isn't that known to affect the rate of corrosion of a metal if you abrade it or scratch it? A. Yes.

Q. It changes the rate.

The Court: Because you increase the surface. That is the main reason. A. That is one reason. If you work metal it tends to corrode a little more than if you do not.

Q. Have you read this current article appearing in the August, 1941, edition of Industrial and Engineering Chemistry entitled "Causes of Corrosion Currents" written by R. B. Mears and R. H. Brown of the Aluminum Company of America? A. I have been too busy sitting here in the courtroom to read any articles.

Q. You know this publication? A. Yes, sir.

Q. Did you ever hear of either Mr. Mears or Mr. Brown? A. I am very sure I have.

Q. Are they competent men in this field? A. As I recall they are. Mr. Mears, I am quite sure I have seen his name.

Q. There is a summary apparently of this article at the top, as I guess they have in these various scientific articles, in larger bold face type, and I am going to read to you and ask you if it is in accord with your experience—"Localized attack of metal specimens is often the result of electrochemical corrosion, not of simple chemical solution. The appearance of specimens suffering this type of attack has led laymen to attribute it to the presence of impurities

in the corroding metal. However, impurities are only one possible cause for this type of attack. Other known or possible causes are: (1) grain boundaries, (2) orientation of grains, (3) differential grain size, (4) differential thermal treatment, (5) surface roughness, (6) local scratches or abrasions, (7) difference in shape, (8) differential strain, (9) differential pre-exposure to air or oxygen, (10) differential concentration or composition of the corroding solution, (11) differential aeration, (12) differential heating, (13) differential illumination, (14) differential agitation, (15) contact with dissimilar metals, (16) externally applied potentials, and (17) complex cells. In cases encountered in practice, 4, 6, 10 and 11 appear to determine the local sites of attack more frequently than do any of the others.

"The magnitudes of potential differences generated by several of the causes listed have been determined experimentally and are given in the paper. In several cases examples illustrating the special attack resulting from these causes are described." A. What do you want me to say?

Q. That is a list of the different factors that can affect the corrosion? A. Sounds like a very complete list and the degree to which they affect corrosion, of course, varies from case to case. Was your question directed to the mechanical working?

Q. No, I was asking if this was in accord with your experience; these are the factors that affect corrosion. A. Yes.

The Court: He has left out of there the different kind of thing—whether it be air or fluid contact. A. This is all water solutions they are talking about. He mentioned the condition of the solution.

The Court: There are seventeen different kinds of things, then, that you agree affect the percentage of corrosiveness or inhibition of anything?

Mr. Lyon: The rate of corrosion, I would put it. To digress for a minute. If you are not familiar with it, I would like you to look at his data here. You may have already experienced it. He shows a difference in illumina-

Dr. Carl F. Prutton

tion of the same surfaces; one being lighted and the other not, would make a difference. A. I think it was kind of dark inside of those tubes.

Q. Well, is that your experience? A. I have no experience with that, and the tubes were dark inside, and the bottles that we had in our thermostat for the lab tests were only a small percentage of the surface area—I mean, only a small percentage of the surface area was exposed to the light. I don't believe that that would account for much. I think you asked me a question about the surface working on metal.

Q. I did, and I thought you answered it. A. All I wanted to say on that was that this wire brush did not disturb a great portion of the depth of the surface, and that is shown in this time of contact of the acid on the oil well tubing. The curve I am going to present tomorrow gives at the start—the rate is very fast, and it is taking off that loose metal and the working metal. The work metal will usually dissolve much faster than the annealed metal, and that occurs in the first few minutes. That is where your 17.8 per cent came from, and that is one of the reasons of running it a greater length of time, because that gives you a more reproducible and more representative value on the reduction of corrosion rate.

Q. Of course, there would be no possible way that the man running this boiler job cleaner through those tubes back and forth could be sure that he had the same abrasions, and the same amount of working on the inside of the tube in one operation, as compared with another; he would just have to take a chance on that and do the best he could?

The Court: Maybe you could make some tests and tell whether the brush took out the dandruff, or whether it just scratched the scalp. A. We did. We didn't make tests, but we just measured what came out, and there was a little black material, which was probably impurities and particles on the surface, but that was all that came out, there was no steel.

Dr. Carl F. Prutton

The Court: The thing I have got a picture of is that brush is a pretty harsh brush, I wouldn't want to brush my hair with it. I just wondered that if you kept on using it there, if you would not keep on getting little particles of iron out. A. You would get some, but it was only brushed through once and pulled back once.

The Court: Every time it goes through then it probably digs a little bit of iron. What is loose will come out easier. A. Yes.

The Court: You take those are almost at right angles, except to the extent you bend them to that wire? A. That is correct.

The Court: I suppose they would tend to abrade? A. And I am perfectly willing to admit that.

The Court: The extent of it I haven't any idea, but I would think it would abrade some. You never did make a test by weighing that iron pipe before and after. A. In the corrosion tests?

The Court: Yes. A. We have those figures and they agree quite closely with the figures in the analysis.

The Court: In that sort of test when did you weigh your pipe? A. After I cleaned it. The figures in general are higher. We took only, took out a few grams with that brushing out operation. It was really the start of another test.

REDIRECT EXAMINATION

By Mr. Owen: Q. I want to ask the doctor if these charts which have been produced correctly represent the data contained in his reports PX-184 and 185? A. They do.

Q. And I will ask you further, did you check the figures on those charts after they were submitted to you by Mr. Rebbeck, after drafts of them were submitted to you by Mr. Rebbeck in connection with his letter of July 11, 1941, Defendant's Exhibit No. 227? A. The figures agree. The results are the same. When we wrote up our

Dr. Carl F. Prutton

preliminary reports we did not want to use any per cent reduction in corrosiveness. We simply wanted to indicate a rate of metal dissolving, and with raw acid, and report the rate of metal dissolving with the acids that we found in the various tests. And that was one of the main points that was mentioned in some of these talks and letters was that the attorneys had decided, well, we are going to do this way, and then Mr. Rebbeck agreed to re-calculate the results and make up a chart which I could check, based on the method of presenting the results.

The Court: Doctor, what would be a definition of inhibition? A. The word "inhibition"?

The Court: As applied to chemistry. A. Not per cent inhibition?

The Court: No. I am intentionally leaving that out. Or I will say an infibitor. Perhaps that would be a little easier. What would you say a chemical inhibitor was? A. An inhibitor is a substance which is usually put into a corroding medium in small amount and which reduces the corrosive tendency of the medium.

The Court: Well, now, you have just testified to using something that inhibited, because inhibited is the reverse of corroded, and when you tell me it stops corrosion you have just used— A. (Interposing): That is true. It is a vague term, but that is my conception.

The Court: Well, Webster says that it is something that prevents reaction. A. That is probably more exact than my statement.

The Court: Well, I am wondering now, is Webster right, and that I have led you into a good definition by quoting Webster? As to what prevents it, is it the coating or the plating that goes on? I have trouble when I read "inhibition" to try to apply it to the results I have got. A. There was some discussion as to whether the material had pulled the teeth out, I think the term was used, of the acid.

The Court: Yes. Webster seems to speak of it, he doesn't say that, of course, but you think, to read the definition, that there was a reaction took place in the corrosive

Dr. Carl F. Prutton

substance, that the reaction took place, that prevented it from corroding by a reaction taking place. Now, that is rather contrary to the plating idea, isn't it? A. Well, there are different types of inhibitors.

The Court: Of course, he doesn't say anything about hydrochloric and he doesn't say anything about arsenic or any of these inhibitors we have talked about, and I take it that it is a term that applies to many things other than hydrochloric acid and steel. A. Yes, very many. Oxidation, lubricating oils.

Mr. Owen: I have here the chemical engineering dictionary, which contains a good definition of inhibitor. (Reading): "Any substance which slows down or prevents chemical reaction or corrosion." Very much like Webster.

The Court: He didn't put the "corrosion" in.

Mr. Owen: Webster did not.

The Court: This is better. Webster just had the broad idea.

Mr. Owen: Just one further point that my associates are a little bit disturbed about, and that is the statement that I was responsible for Dr. Prutton's reports, and they are very anxious to have me read these letters which were offered, but I don't necessarily want to do that, if—

The Court: I will say this on the record, that I think in most courts they would never have found out about that, and I think that what has been done is usually done; they talk together, and they work together. Of course, you have the natural prejudice that anybody has, trying to honestly represent the people he is working for; and it is easier for you to see your side, and the others to see their side, than perhaps it is for me to see either of your sides. I can see that that enters into it. I am not feeling cross towards anybody, or thinking ill of anybody. If that is what you have got in mind, you don't need to spend any time on that.

Mr. Conner: Mr. Lyon had said, he was having you (Mr. Owen) telling Prutton what to report.

The Court: Most judges don't get into all that sort of thing, but I do, and it is helpful to me. I think it is a good thing to do myself.

Dr. Carl F. Prutton

Mr. Owen: That is all, then, Your Honor.

The Court: You see what I am doing, I am putting my own approval on what I have done.

Mr. Owen: That is all I have, Doctor.

The Court: I am putting my own probe in.

Mr. Owen: I wasn't disturbed about it, but my associates were.

The Court: I say feel perfectly free to put in anything you want, but I am not surprised at what I found out at all, and I am going to be surprised if I don't find that the others have made some experiments that they think they made a mistake in.

Mr. Owen: I hope that their insides will be turned out as thoroughly as ours have been.

The Court: I will try just as hard to do it.

Mr. Owen: Dr. Prutton has made that sketch I requested. I would like to have him explain it. I will give it exhibit number PX-234.

(Whereupon the sketch was marked PX-234.)

Dr. Prutton: Now this chart was prepared from data that was obtained when samples of this 1¼" oil well tubing 1" long were tested for the amount of corrosion in this standard laboratory test that we employed which gave results comparable, as we felt, with the large scale results. We tested the rate of corrosion using different lengths of time of immersion of the specimens in the acid. If we plot vertically over here (witness drawing on blackboard) the rate of corrosion or the grams of iron dissolved per square meter of surface per hour of contact, those numbers are plotted vertically, and horizontally we plot the time of test or time of contact in hours, and we start here with 2 hours, 4, 6, 8, 10, 12, going out to 16 hours; and here (indicating) we plot, let's take a maximum of 125 grams, 100, 75, 50 and 25.

The first tests were made upon 15% chemically pure hydrochloric acid and the time of test was 3 minutes. The rate at which the iron dissolved, figuring from the weight loss from the specimen and area surface exposed, time, the

Dr. Carl F. Prutton

rate was for 3 minutes which was practically over here and against the axis was 107 grams of iron dissolved per square meter of surface per hour of contact. That is simply the rate at which the iron was dissolving over this 3-minute period (indicating on the blackboard). Then the next test was run, using a section of oil well tubing in 15 per cent C. P. hydrochloric acid, and 6 minutes was employed. Now, at 6 minutes, the average rate of solution of the iron was 82.2. The next test was run for 12 minutes, still over in close here (indicating), and was 77.8. You see, this was 82.2, and this is 77.8, at 12 minutes. The next test, and these are entirely separate tests that were run in duplicate, this is a 30-minute test, which would be a half hour, and this is 76. In other words, the rate of dissolving of the iron by the acid was very rapid here, and then in a few minutes it came down to practically a constant rate. Now, 3 hours, in the 3-hour test the rate was $72\frac{1}{2}$. 6 hours, 71.8. At 9 hours it was 70. I will put the numbers opposite each point. In 16 hours, the rate is—I have it indicated on the graph here, but I do not have it numbered. It is about 60, out here (indicating), plus or minus 2. That is just from the graph, which I took from the data. I don't recall the number. Now, this curve for C. P. hydrochloric acid shows—

The Court: That is almost a tangent, after it reaches 3 hours? A. 12 minutes (indicating). This is 12 minutes. This is 6 minutes here (indicating), and this is 12 minutes here, and then 30 minutes. Now, if we take an acid containing copper, lead and iron in a concentration of—this particular acid happened to be three parts per million of copper, and a thousand parts of lead, just a little higher in lead. Then the defendant's acid, or the acid that we obtained from the Menaul tanks that we employed, for a laboratory test, gives us the same rate substantially at the 3-hour test—in the 3-hour test with this acid containing lead, copper and iron, 3 minutes gave 80 grams per square meter dissolved. Six minutes gave 69.8. And 12 minutes 40.4. And 30 minutes 34.8. And 180 minutes 22.2. And

Dr. Carl F. Prutton

360 minutes 17.6. Now, 540 minutes, or 9 hours, 18.4, which is a little higher but substantially the same. Now, if you draw a curve through these points as well as you can, with this acid containing copper, lead and iron, you get a curve of that type (indicating). The difference between the height of this line and the height of that line (indicating) is what we have been talking about as this percentage inhibition, if you express it in percentage of the total height, or if you just take the difference here you would have a reduction in the rate of corrosion. For example, if we have an iron tubing in 15 per cent C. P. acid and we run a test for three hours, we get a rate of 72.5 grams of iron dissolved per square meter per hour. If we run it with this lead, iron and copper containing acid, 22.2. Now, these figures are quite representative of and are within one or two units, this of the crock acid that was used in our tests, in all the tests we ran on the crock acid, and this of the Menaul or synthetic acid. In other words, within two or three down here and two or three up here (indicating).

Mr. Owen: That upper line, Doctor, you said all the tests you ran? You mean all? A. These were run with C. P. acid.

Q. Without any additions? A. Without any additions whatsoever. Now, our actual crock acids were a little lower than that. We ran a curve for those, but they were somewhat lower in the three hour test, but here we have this C. P. and the difference between the two is the inhibition. Now, in a letter that I wrote to Mr. Rebbeck I gave him some preliminary numbers for this difference up here, or three minutes test, which showed about 18 or 20 per cent inhibition. At three minutes this height is 20 per cent of the total height, and that, as I explained, I am quite sure is due to the loose iron that is on the surface being attacked at a more rapid rate right at the beginning, to loosen that up. You see, there seems to be lost practically no weight. All this loss of 107 grams per square meter per hour, you only have it on one-twentieth of an hour, and the amount dissolved is that loose fuzz on the surface.

Dr. Carl F. Prutton

When you get down here to a going over twelve minutes you are getting down to where the drop in corrosion due to the addition of these metals reduces the corrosion about fifty per cent, that is, the corrosiveness or rate of corrosion of acid containing copper, lead and iron is about half of the total height of the corrosiveness of the C. P. acid. When you get over here it is 60 to 70 per cent, but between 12 minutes and out here as far as we went the difference here is not tremendous.

Now, that was the figure that was cited out of this letter that was written and the reasons for the running of this curve was in explanation of what we felt was happening in the rate of corrosion samples.

RECROSS EXAMINATION

By Mr. Lyon: Q. In accordance with what you have just illustrated on the blackboard and with this curve you have produced the per cent of reduction in corrosion as illustrated on the chart such as PX-189 or the one in front of you, which is one of the corresponding charts would be different for each difference in time, isn't that correct? A. At any time between 12 minutes and about 7 or 8 or 9 hours out here, if we measured the difference might be 10 or 15 per cent.

Q. As against what? A. As against,—that is, 50 compared to 65 or something like that,—55 compared to 70.

Q. Now, I want to ask you as follows, and you can take this down if you want to, in taking the figures you have put on the blackboard, the per cent of reduction in corrosion in the system that you have illustrated there for three minutes would be 25.4; 6 minutes, 15.0; 12 minutes, 48.0; 30 minutes, 54.0; 3 hours, 69.4; 6 hours, 75.5, and 9 hours, 73.7. If those are not correct, it will just take you a minute to check them and I wish you would give us the actual differences in per cent, using the method of calculation that were used in these charts, such as PX-189 for the 3 minutes, 6 minutes, 12 minutes, 30 minutes, 3 hours, 6

Prima Facie Proofs

hours, and 9 hours. A. Well, do you want the exact figures, or a general statement? You don't want any exact figure?

Q. Just substantially. A. Those are substantially right, I would say.

Q. The ones that we gave you? A. Yes.

Q. We calculated them in a hurry. A. They are close. In other words, here is—substantially they are right. I would say, just looking at them, I would say they are substantially correct.

Mr. Owen: There is one other point I want to cover. Your Honor will recall that back in the beginning of this case we introduced as PX-10 a chart with some parallel streams and a delta at the bottom, showing the results of the Grebe-Sanford patent, and how it has grown in a few years.

The Court: Yes.

Mr. Owen: And we were criticized, or the witness Mr. Penhaligan was criticized on cross examination because he had included in those figures certain treatments that were made for mud removal in the California field and some for stuck drill pipes, and Mr. Penhaligan, who is not a chemist and is the auditor there, in making up his figures included all of those because they went through his books as business for Dowell X. In view of the criticism we had Mr. Penhaligan go through his books again and take out all those California treatments and all the stuck drill treatments and things of that kind, and I would like to get this in by submitting it to counsel and avoid recalling Mr. Penhaligan, if that is possible.

The Court: Submit it to them and let them look at it.

Mr. Owen: Then Mr. Penhaligan has also made up a list of treatments made by licensees other than Dowell, which I would like to offer, and those are made up by months, beginning with the year 1934, and ending with the year 1940.

Prima Facie Proofs

The Court: Have those marked right now and offer them and then I will wait and see what they say about it later on.

Mr. Owen: I will have the sheet showing the deductions from the figures shown on our chart PX-10 marked PX-232, and the sheet showing treatments made by licensees of Dow, other than Dowell, will be marked PX-233.

(The sheets were thereupon marked PX-232 and PX-233.)

Mr. Owen: We will hand these to defendant's counsel for study.

Mr. Owen: A couple of days ago we had identified as PX-232 and 233 two sets of data prepared by Mr. Penhaligan the first of which shows the figures of total treatments, which are included in PX-94; that is, the total treatments made by Dow and Dowell, and the question was asked whether it included certain mud treatments in California, and treatments for the removal of stuck drills, and I had Mr. Penhaligan recheck it and deduct treatments which related to the removal of stuck drills and the California treatments, and the corrected figures are given down at the bottom, opposite the words "Net total." I want to know whether defendant will stipulate that Mr. Penhaligan would testify to the correctness of these figures if recalled.

Mr. Lyon: If I understand it, on Exhibit 232 the individual jobs deducted from the previous figures which were on PX-94 represent jobs where the acidizing was not to increase the production?

Mr. Owen: That is right.

The Court: These are actual figures?

Mr. Owen: These are actual figures taken from our records.

Mr. Lyon: I am willing to agree that he would testify to these figures of these deductions if brought in, but in connection with that I would like to offer these two advertisements of the Dowell Company in connection with the importance and the character of the operations which were formerly included in Exhibit 94, and which now will be deducted from Exhibit 94.

Prima Facie Proofs

Mr. Owen: I don't have any objection to that.

Mr. Lyon: The first one is entitled "Out In Front." It appeared in the Petroleum World for September, 1938, and it is entitled "Out In Front," and has an explanation, "Out in front with lime scale removal.

"Removal of lime scale is among the important specialized services Dowell has perfected expressly for California producers.

"Lime (calcium carbonate) scale presents a special problem well worth solving, as these deposits, led by water, block off producing formations and production declines abnormally.

"Dowell, after long study and practical field work, has perfected a special service that leaves nothing to guesswork. Dowell uses inhibited acid which protects metal liners, while rapidly dissolving calcium carbonate."

And I want the court to bear this in mind in connection with this, what the Gypsy did, which was read in evidence, down in Oklahoma, where they were doing exactly this, and Dowell is advertising this.

(The advertisement above referred to was thereupon marked Defendant's Exhibit No. 242.)

Mr. Lyon: I will now produce and ask to be marked as DX-243 a page advertisement of the Dow Chemical Company in the Petroleum World for January, 1939, the advertisement reading:

"Dowell scale removal treatment.

"For California producers.

"Dowell Chemical removal of carbonate scale increases profits.

"As indicated so graphically in the chart reproduced above, actual results obtained in numerous Dowell treatments for carbonate scale removal demonstrate the great value of this special service for California producers. It is a service that is proving itself, again and again, an exceedingly profitable investment for the operator.

"Dowell carbonate scale treatment and technique of

Prima Facie Proofs

application have been carefully developed and perfected to meet conditions as found in California wells.

"Inhibited acid, to which a wetting agent is usually added, is pumped through the casing head into the annular space between the tubing and casing. The acid comes in contact with the scale both on the outside of the tubing and, still more important, on the perforated section of casing or liner.

"Treatments and technique of application vary according to conditions as tested and determined by Dowell technicians. And case histories tell the same story—restored production and increased profits."

We offer that, which on its face is obviously the same treatment that the Gypsy was using.

The Court: Except the inhibitor.

Mr. Lyon: Well, the Gypsy had the inhibitor in. You remember Dr. Wescott of the Mellon Institute recommended the inhibitor.

The Court: Yes.

Mr. Lyon: And they put the inhibitor in down in Oklahoma.

(The advertisement above referred to was thereupon marked Defendant's Exhibit No. 243.)

Mr. Owen: If Your Honor please, PX-233 is a statement prepared by Mr. Penhaligen, showing the number of treatments made by licensees of Dow under these patents, other than the Dowell Company, and that shows a total of 2277 treatments, and does not include treatments made by California licensees.

Mr. Lyon: I would agree that your witness would testify in accordance with this Exhibit PX-233, but in accordance with Exhibit 232, these deductions that have been made from Exhibit 94, am I correct, Mr. Owen, that you have deducted from Exhibit 94, in this Exhibit 232, the scale treatments, or the jobs that have been done in accordance with these last two advertisements that I have produced here; or are they still included in these figures that remain after the deductions appearing on Exhibit 232?

Prima Facie Proofs

Mr. Owen: It is my understanding that they are excluded, but I will have that checked.

Mr. Lyon: Would you have that checked because I would like to know whether the figures that are presented here under the patent in suit include these lime scale removal jobs, or not. For obvious reasons, I think the court should know that.

The Court: He will produce that, and I will admit 232 and 233.

Mr. Owen: Now, in connection with depositions taken in this case in Duncan, Oklahoma, Mr. Clason produced a number of acidizing tickets which were marked in that deposition PX-7 and numbered from 1 to 113, there being a total of 113 tickets.

I wish to offer those tickets as an entirety here as PX-244.

(The defendant's acidizing tickets referred to were thereupon marked PX-244.)

Mr. Owen: Then I wish to call upon defendant to produce the orders relating to these particular jobs covered by these 113 tickets. The orders, I will say, contain information that is not contained on the tickets, and that is the reason I am asking for them.

Mr. Lyon: We haven't got them here. It would require a considerable work to go back through the records of the company and dig out all the orders which these tickets correspond to. The tickets were produced when they asked for them. They have never asked, as far as I know, for the orders, and I don't see how we can have them here now in time, and I don't think we should be asked to go get them. I don't understand the orders have any information on that the tickets haven't got. What could be the information you want? Maybe we can cover it in some other way.

The Court: These are orders from the customers?

Mr. Lyon: Yes; but these are the actual operations. I don't see where all these jobs come in on this case in any special way in this hearing. They are all the jobs ever done

Prima Facie Proofs

in Michigan up to the filing of this complaint, and I can't see that those individual jobs are involved unless we come into an accounting, and what is the information you want off the orders? We want the court to have any information that the court wants, but to go find 113 orders through our books back four or five years ago, is a job. They don't really need them. What is it you want to prove by it? Maybe we can make some statement that we could prove—

Mr. Owen (interposing): We want to prove the depth of these wells and the length of the casing, the distance from the bottom of the casing to the bottom of the well, and the length of the tubing.

Mr. Lyon: Well, aren't you willing to accept the four wells which you took your samples from here as typical of what the defendant was doing here in this district?

Mr. Owen: Yes.

Mr. Lyon: You have that data for those four wells.

Mr. Owen: We have that, yes, for those four wells, and I can't answer that because I don't know whether it would be typical, but I will consider it, and in the meantime I would like to have you endeavor to get that information from your home office.

Mr. Lyon: We can't get it here. It would take considerable time. I am not sure how long. Probably a couple of weeks, to go through all the records. This stuff is all permanently separated in the files of the company, by oil companies. Now, these oil companies, for instance, like the Ohio Oil Company operates in many places in the United States. We would have to check through all of their orders to pick out those that came and were filed under their name from Michigan, and then they would have to be sent up here.

Mr. Owen: I am sorry you didn't understand my request. I thought I made it perfectly plain. I introduced photostatic copies of just what you have produced here today, and I requested at the same time that you produce these agreements.

Mr. Lyon: Well, I understood, Your Honor, that this

Prima Facie Proofs

case was being tried on the basis that the four wells that the specific samples were offered from were typical of what they alleged was an infringement. Now, they have the data on those four wells.

The Court: Can't we get that, Mr. Owen, and see what that does show with reference to those four? Does that show you what you wanted to prove?

Mr. Owen: As to those.

The Court: If it does, for one well, and you agree that is typical of the others—

Mr. Owen (interposing): As to those four wells, it does show the information, and we will consider that this evening.

The Court: Was favorable to you.

Mr. Owen: I don't know whether it is favorable or unfavorable. All I want—

The Court: But I guessed the point to it, you want to show the acid would come in contact with the iron?

Mr. Owen: Right.

The Court: That is what you want?

Mr. Owen: Right.

The Court: Does it in those wells?

Mr. Owen: I think it does.

The Court: Well, then, say it is typical of the others, then you have shown you come in contact with all those wells, I take it?

Mr. Lyon: He means by "coming in contact," he wants to know how long it takes it to go down the pipe.

Mr. Owen: How long it is in contact?

Mr. Lyon: With the pipe going down.

Mr. Owen: The length of the tubing has something—

The Court: On that now he says he is willing to take those four as typical of how long they take, and those are the four—they did not make them out, I don't reach the conclusion that they have selected those that will show the best for them.

Mr. Owen: Your Honor, I have some figures here that have been gotten up from the books and records of the Dow

Prima Facie Proofs

and the Dowell companies, regarding their advertising expenditures during 1932, 1933 and 1934, and also as to the amount of business transacted in this acidizing business during those years. I would like to read them in the record, with the understanding—

Mr. Lyon: I have not seen them before, and I do not know what they are.

Mr. Owen: I will defer that then with the understanding that I may put it in later. I will get a witness here who will prove it.

The Court: You can put it in later then.

Mr. Owen: Yes, I can put it in as part of my rebuttal.

The Court: Yes, or at any time I will interrupt the other side long enough for you to put it in, if you want to. I will make it that convenient for your witness. While I like to have a plaintiff, when they are putting in their proof, put in all they have got in mind, and the defendant all they have in mind, why, if something is overlooked, I want them to put it in later, if they discover that something has been overlooked. I don't want you, for instance, in announcing that you have rested here to be uneasy for fear that you have forgotten something. Any time before the final decree will be time enough.

Mr. Owen: Yes, Your Honor. The next thing I have is a printed price list, or, it is called service price schedule 110 of Dowell, Inc., which became effective June 23, 1937, and I am offering it for the purpose of showing that the blanket service, the jelly seal service and the surface tension reducing agent were not charged for within certain limits. For instance, the Dowell X is inhibited hydrochloric acid solution. Dowell XF is Dowell X, with the surface tension reducing properties for use in low pressure wells; and the charge item No. 4—no, item No. 1, is 500 gallons or less Dowell X or XF service. Then it gives the price of the treatment. There are three different classes here, evidently for different locations, and that is all on the price list, so I won't read it.

Prima Facie Proofs

(The price list referred to was thereupon offered as PX-245.)

Mr. Owen: Now, the only other exhibits I want to offer in connection with my prima facie are two sets of tables that Dr. Bartell furnished to Mr. Lyon, at his request, and I would like to offer this set in connection with the copy of Dr. Bartell's letter to Mr. Lyon dated August 4th, which states:

"Acting upon your request I am sending you herewith the experimental data which was obtained in our acid corrosion tests with samples numbered 1 and 2 from the Stella Wilcox Well." I will offer that carbon copy of the letter and the four sheets of data as PX-247.

(The document above referred to was marked PX-247.)

Mr. Owen: I offer as PX-248 carbon copy of the letter written by Dr. Bartell to Mr. Lyon August 4th, reading as follows:

"Acting upon your request I am sending you herewith the experimental data which was obtained in our acid corrosion tests as presented in and described in our Table XIX (PX-167)," and attached to that copy are 3 sheets of data.

(The document above referred to was marked PX-248.)

Mr. Owen: That closes my prima facie case, Your Honor, with that reservation I made, which you granted.

Don Hathorn

DEFENSE PROOFS

DON HATHORN,

a witness called by defendant, testified as follows:

I am an engineer in the employ of the defendant, Halliburton Oil Well Cementing Company and live at Duncan, Oklahoma. I have been for some time in the Patent Department of that company, assist the Patent Department in making tests and tabulating data. I have conducted certain tests for this case with reference to the operation of the Menaul method of protecting the tanks employed by the defendant in acidizing oil wells. Assisting me in these tests I had Menaul in at different times, and I had four different assistants from Halliburton laboratory, working under my supervision. They were Frances Anderson, George Mirham, Bill Barrett and Zema Ballinger. The work they did was done under my supervision and recorded under my supervision. All of this work—that was done by my assistants and by me personally—was recorded at the time it was done in certain books of original entry. I have those books here and will produce them.

(Witness produces books.)

Everything is recorded in this, but some titration numbers are in here (indicating another book), but they are transferred to this book (indicating).

Mr. Lyon: The book which the witness has just identified is offered as DX-277.

(The book referred to was thereupon marked DX-277.)

I might say that there are some other data in there which do not relate to this lawsuit (indicating) but all of the actual determinations made in the tests on the Menaul tank conducted by me, or under my supervision, are entered in this Exhibit DX-277. This is the book of original entry of those tests.

Don Hathorn

(The second book referred to was thereupon marked DX-278.)

This book was used in recording some of the titrations, but being as this other book was in use on other experiments that were going on at the time, they were recorded in this second book, and then transferred to the first book. By titrations I mean the chemical tests as distinguished from the weighings and readings which are in 277. These titrations were recorded in 278 as the book of original entry, and then they were transferred to 277. I have taken the readings and titrations recorded on Exhibits 277 and 278, and plotted the results of the various experiments in the form of curves, and in doing so I made certain calculations. I have the book in which I made the calculations (producing a book).

Mr. Lyon: I will ask that this book be received and marked DX-279.

(The book referred to was thereupon marked DX-279.)

Mr. Lyon: I will ask that the first one of these curves, entitled "Hard steel tank No. 1," be marked DX-280.

(The curve referred to was thereupon marked DX-280.)

Mr. Lyon: That is the first sheet. The various sheets are all attached together. The second sheet is marked "Hard steel tank No. 2." I will ask that that be marked DX-281. The next sheet is marked "Hard steel tank No. 3." I will ask that it be marked DX-282. The next sheet is marked "Soft steel tank No. 4. Sheet 4." I will ask that it be marked DX-283. The next sheet is marked "Soft steel tank No. 5. Sheet 5." I will ask that that be marked DX-284. The next sheet is entitled "Hard steel tank No. 1. Sheet 6." I will ask that that be marked DX-285. The next sheet is entitled "Soft steel tank No. 4. Sheet 7." I will ask that that be marked DX-286.

(The sheets referred to were thereupon marked DX-281 to DX-286.)

These various curves that appear on Exhibits DX-280 to 286, respectively, were drawn by me from the data observed in the experiments recorded in Exhibits DX-277,

Don Hathorn

278, with the calculations in Exhibit 279, and to the best of my ability they correctly set forth graphically the results of the experiments recorded in those exhibits. I have an index prepared which will enable anyone interested to readily find in Exhibits 277, 278 and 279 the various values which are plotted on the curves, Exhibits 280 to 286 (producing document). It is entitled "Index for corrosion experiments."

Mr. Lyon: I will ask that that be marked DX-287.

(The index referred to was thereupon marked DX-287.)

Mr. Lyon: Will you take these different sheets, identify them by exhibit number, and tell us what the experiments were, briefly, the results of which are plotted in the individual curves appearing on the sheets, because, as noted, each one of the curves on each sheet is numbered so that they can be found on the index? First, Exhibit 280, curve No. 1; what is that curve? A. It is a curve of commercial acid placed in an iron tank, steel tank, which is made of the same material as the defendant's truck tank, and the solution of hydrochloric acid was agitated and samples taken at each one of these points along the curve and the test continued for about 42 hours. I have the tank that was used in that test. The tanks are over here (indicating). This (indicating) is hard steel tank No. 1.

Mr. Lyon: I will ask that that be marked DX-288.

(The tank referred to was thereupon marked DX-288.)

The other tank is what we call "Soft steel tank." That was used in the soft steel tank experiments. We had two soft steel tanks, No. 4 and No. 5; this is No. 4. We had three hard steel tanks, Nos. 1, 2 and 3, and this is tank 1 (indicating).

Mr. Lyon: We ask that the soft steel tank produced by the witness be marked DX-289.

(The tank referred to was thereupon marked DX-289.)

The soft steel tank, Exhibit 289, is made from material corresponding to well pipe. Well pipe is made out of soft steel. This was to show the action of acid in my tests on oil well pipe, on the iron used in well pipes.

Don Hathorn

The Court: Both the casing and the tubing? A. This happens to be a piece of casing, sixteen inch casing. We didn't use tubing because it would be too small. And the hard steel tank Exhibit 288 was made from hard steel and the defendant employes hard steel in its truck tanks. This is a piece of the steel.

Mr. Lyon: So as to show the effect of acid on the kind of steel that is used in the truck tanks as distinguished from the pipe.

The Court: Fine.

Mr. Lyon: Now let's get back over to the curves. Now, will you describe the experiment made the results of which are recorded in Curve No. 1 on Exhibit 280, just briefly, so we can tell what kind of experiment it was? A. Well, Curve No. 1 was a plain commercial hydrochloric acid placed in the hard steel tank No. 1 and agitated with the motor you see sitting on the tank over there, and a glass stirring rod used, for agitation, the R.P.M. of the stirring rod was about sixty revolutions per minute. And at each one of these points you see on the curve here a sample was taken, and an analysis for iron was run on that particular sample and recorded there, the amount of iron in ounces per thousand gallons of acid solution was calculated and plotted, versus time in hours. Also, I have a scale here which is iron content of acid solution in parts per million by weight, which was put on there to correspond to the values that the plaintiff gave us in their answers to interrogatories.

Q. Now, in making the test the numbers of which are plotted in the Curve No. 1 on Exhibit 280, did you have any lead plate bonded in the Tank No. 1? A. No lead plate at all in contact.

Q. Then this curve No. 1 on Exhibit 280 is a curve showing the rate of corrosion or dissolution of the hard steel tank in the absence of any lead plate using commercial hydrochloric acid; is that correct? A. That is correct.

Q. And that commercial hydrochloric acid is the same kind and make of acid as the defendant employes in its

Don Hathorn

acidizing operations? A. Yes. All these tests were run with fifteen per cent acid.

Q. All right. Now tell us what curve No. 2 is: A. Curve No. 2 was run in the exact procedure, however it was a different date. Curves 1, 2 and 3 were all run in the large steel tank No. 1 without any lead plate. As near as we could tell, exactly the same procedure. 1, 2 and 3 were run the same. They weren't the same acid. They were out of the same shipment of acid.

Q. I understand that you use one acid for the test, then you take another batch of acid for the second curve, is that right? A. Yes. Same base acid, same shipment.

Mr. Lyon: That shows, Your Honor, the three curves rather than an average. In that particular case, the three results instead of an average.

Mr. Owen: What make acid was it? A. Well, I just turned over to the purchasing department and told them to order so many carboys of the same acid we used in the field. I believe in that case it was Grasselli acid. I don't know.

Mr. Richmond: Mr. Clason can give the name.

Mr. Clason: Grasselli Chemical.

Mr. Lyon: You mean all these curves were made by the same Grasselli acid? A. Yes.

Mr. Owen: The same tank used for these tests, curves 1, 2 and 3? A. All on this sheet were made in one hard steel tank, and then we had three different sheets for three different tanks.

Mr. Owen: And the same shipment of acid? A. Yes, sir.

Mr. Lyon: Unless otherwise specified, you used the same shipment of acid for making all these tests? A. Yes.

Mr. Lyon: Now, I don't think I need to go into the date of the runs because they are all tabulated in Exhibit 285.

Mr. Wiles: The variation isn't attributable to temperature change at the different dates? A. Well, it might be because the same temperature might not prevail last Feb-

Don Hathorn

ruary in the building as it did this summer when we finally wound up the tests.

Q. (By Mr. Lyon): Now, curve No. 1, according to Exhibit 285 was made on March 31, 1941, Curve No. 3 made on March 5, 1941, Curve No. 2 was made on June 10, 1941. This was an air conditioned room in which these tests were made, is that correct? A. Yes. However, the temperature would vary from night and day too, you see.

Q. Well, these tests were run continuously, were they not, the number of days that your curve indicates? A. Yes.

Q. And are these the dates at the start of the runs? A. Yes.

Q. So Curves number 1 and 3 were both started in March, were they not? A. They are marked.

Q. And in that air conditioned room in your country there wouldn't be much difference in temperature as compared with one day in March to another, would there? A. No.

Q. And how much difference would there be in your air conditioned system between a date in March and a date in June in that room, if you know? A. I would say not over 5 or 10 degrees.

Q. Now will you take up Curve No. 4 on Exhibit 280 and tell us what that is? A. Curve No. 4 was commercial acid with a lead plate bonded to the side of the tank, as you see by the exhibit.

Q. Will you explain the bonding of this lead plate in Exhibit 288, which is a hard steel tank. Is the lead plate in the exhibit now bonded as it was in the test? A. It is. The lead plate that is bonded to the steel tank is the same—has the same surface exposed to the acid relative to the iron surface as the lead plate used in the defendant's truck tank (indicating). The lead plate was insulated by rubber stoppers from the bottom of the tank.

The Court: Is the lead in this tank exposed on both sides or on one side?

Mr. Owen: On both sides. A. After these experiments with the lead plate were run for twenty-four hours, the lead

Don Hathorn

plate was cut across here, the top, and then a stand was moved up and this lead plate was clamped in the acid, but not in any way connected to the steel tank, so as to leave the plate suspended in there, but no electrical contact except through the electrolyte.

Q. Now, this lead, what did you order, or, how did you get this lead plate; what kind of lead is it? A. It is the sheet lead just cut out of a piece of sheet which would ordinarily be used in the defendant's tank.

Q. Do you know what grade of lead it is? A. No; it is just the commercial lead.

Q. At the time you made these tests did you have any information, or anything which caused you to believe that the plaintiff in this case was relying on copper acting as an inhibitor in the Menaul system and there was any claim that there was copper in the lead or in the tank surfaces? A. No, I didn't.

Mr. Wiles: After you cut off the lead plate, how did you say it was held when the further tests were made? A. We moved a stand similar to this up here (indicating), and clamped this lead plate to the stand, metal stand.

The Court: Was that metal in contact with this part (indicating)? A. No, it wasn't, it was setting out here on the wooden table, you see.

Mr. Lyon: So what you did—we will point out the curves where you did it, and the end of twenty-four hours in these tests you disconnected the lead plate from the steel? A. Yes.

Q. Just to show what effect it made on the continued running when it was disconnected?

The Court: A good way to find out. All right.

Q. (By Mr. Lyon): Now, this lead plate in Exhibit 289 is subject to the same testimony and the same explanation? A. Yes.

Mr. Wiles: That is the soft steel tank? A. Yes.

Mr. Lyon: And these tanks, Exhibits 288 and 289, haven't been altered in any way as to their surface condition since you ran the experiments that your exhibits report? A. Except that they have rusted a little.

Don Hathorn

Q. They have rusted a little since then, but I mean you haven't done anything, burnished them or polished them or removed any corrosion, or anything of that kind?

A. No.

Q. And any pitting that existed as a result of any of those experiments is still there? A. Yes.

Mr. Wiles: Do you have the composition of the steel in these tanks? A. No, I don't have.

Q. (By Mr. Lyon): But they are in the regular well pipe and the regular tank steel? A. That is right.

The Court: What did you do, take a casing and split it open and weld it on? A. We took a piece of 16-inch casing and cut out this piece about 14 inches high and then took a piece of the same material and made the bottom, welded the bottom in. It is the same material as the casing.

The Court: You took just one casing and cut it off and put the bottom in? A. Yes.

Mr. Lyon: How did you make the other hard steel tank, Exhibit DX-288? A. It was made out of a piece of flat steel, came out of the same stock as they make the defendant's tanks.

Q. How about the welding rods that were used? A. It was the same material as the tank itself.

Mr. Owen: Are the two tanks of the same capacity? A. Yes.

Mr. Lyon: And you used a lead plate in each case whose exposed surface relative to the exposed surface of the tank would exactly correspond to that relation in the defendant's truck tanks? A. I don't know whether it would be exactly or not. As well as we could calculate it.

Q. I mean, you calculated it, and, to the best of your ability, that is the relation? A. Yes.

Mr. Allen Owen: I would like to ask a question about the bottom of this soft steel tank. Where did you get that material? A. Out of a piece of casing.

Mr. Allen Owen: You took a piece of casing and flattened it out? A. Flattened it out.

The Court: Flattened out a piece of the same casing and then cut it out? A. That is right.

Don Hathorn

Mr. Wilber Owen: Did you heat the steel to flatten it? A. No. I don't know how they flattened it. They have hammers there in the shop.

Q. (By Mr. Lyon): They have big hammers down there that could easily flatten out one of these pieces without heating it, couldn't it? A. Yes.

Mr. Wilber Owen: You know that they didn't heat it? A. What they did, they took a welding torch and just cut the casing in two and then put it under the hammer and flattened it out. Yes; I am sure they didn't heat it.

Mr. Lyon: All right. Now, can we go back to curve No. 4 on Exhibit 280, and tell us how you made the test plotted on that curve? A. We ran the commercial acid with the lead plate bonded to the tank for twenty-four hours, taking samples, and at the end of twenty-four hours we disconnected the lead plate and left it suspended in the solution, insulated from the iron tank I described previously, and then took samples for an additional twenty-four hours.

Q. In preparing these curves, you have actually placed on the sheets the dots or points which your results or your measurements actually show, and by noting on these curves the dots you know exactly what readings and what calculations you made, is that right? A. Yes, sir.

Q. It is only necessary by means of this index to find in Exhibit 277 the values and the calculations that result in those particular readings? A. Yes, sir.

Mr. Owen: I would like to ask at this point whether you made any corrosion tests in those tanks without any lead plate connected with them? A. Yes. One, two and three were made without the lead plate. 4, 5 and 6 were made with the lead plate in.

Mr. Lyon: You have explained curve No. 4. Tell us how the test was run on which curve No. 5 was based? A. Curve No. 5 was run in the exact procedure as curve No. 4.

Q. How about curve No. 6? A. Curve No. 6 was the commercial acid, plus the Tergitol, which we originally felt might have been classified as an inhibitor, and it was run

Don Hathorn

with the lead plate connected for twenty-four hours, and then the lead plate was disconnected.

Q. This legend on Exhibit 280 reading "Lead plate disconnected, tank not cleaned," pointing to curves 4, 5 and 6, is to indicate that at the end of the twenty-four hours the plate in those three experiments was disconnected, and then the experiment continued with the lead plate suspended, and not connected, and without stopping to clean the tank? A. Yes.

Mr. Allen Owen: Was the tank cleaned between runs? A. Yes, it was.

Mr. Allen Owen: How? A. By putting in boiling sulphuric acid, and it staying in there about between 45 and 50 minutes, and at frequent intervals they would take it out, and if there was any contamination visible, they would brush it out with a wire brush; and then it was rinsed out with hot water, and then rinsed with hydrochloric acid.

Mr. Owen: How much Tergitol did you put in that last experiment? A. It was two-tenths of a per cent by weight.

Mr. Conner: Which Tergitol did you use for the last curve? A. Tergitol 4.

Mr. Lyon: At this time, in order that Your Honor may not be worrying about something that you don't need to worry about, I would like to read in evidence the answer of the plaintiff to interrogatory No. 7 proposed by the defendant to the plaintiff, and this was subscribed and sworn to on June 2, 1941, and reads:

(Reading): "7. Answer to Interrogatory No. 7. Plaintiff will not contend that the presence of 'Tergitol' in the acid solutions used by defendant in treating oil wells constitutes infringement of Grebe and Sanford patent No. 1,877,504."

Mr. Lyon: Will you explain the test by which the various curves occurring on this exhibit was made? A. These curves were made on tank No. 1 which was a hard steel tank, made similar to this other tank. Curve No. 1 was commercial acid, with no lead plate. Curve No. 2 was

Don Hathorn

commercial acid plus Tergitol, .2% by weight, with no lead plate.

Q. The first one is just the acid without any lead plate; the next with Tergitol without any lead plate at all?

A. Yes. Curve No. 3 was commercial acid plus lead plate, with the lead plate disconnected after 24 hours. That was, it was cut and taken out, acid removed from the tank this time, and the tank thoroughly cleaned. And then the lead plate suspended back in the acid, the acid put back in the tank and the lead plate suspended.

Q. But not connected? A. Not connected in any way.

The Court: In other words, that means to me, as I look at it there, as quick as the lead was disconnected the acid went to eating the iron? A. The reason for cleaning this tank was to remove polarization or lead that was deposited on the steel tank.

Mr. Owen: Did you change the acid at that point? A. It is the same acid. Removed from the tank, placed in a crock, and after the tank was cleaned it was poured back into the tank.

The Court: Of course they cleaned it, so that if the others had done a good job, and all you claim for it, it might have such a coating on that it at least would take it some time to get started? A. Yes. Here (indicating) curve No. 4 is run in the same way, except the tank wasn't cleaned, and the curve came on out and eventually went up.

Mr. Lyon: What about curve 5? A. Curve No. 5 is commercial acid with lead plus Tergitol and the lead plate disconnected after twenty-four hours and the tank cleaned the same way as curve No. 3.

Mr. Lyon: The reason for these Tergitol duplications. Your Honor, the plaintiff doesn't contend the Tergitol is an inhibitor in measuring any claimed inhibitors or rate of corrosion in the defendant's acid; in order to be parallel with what the defendant uses; the Tergitol should be in there, because it is in the acid the defendant employs.

Q. (By Mr. Lyon): Now, will you turn over to the next exhibit, Exhibit 282, and explain the curves on that

Don Hathorn

exhibit? A. Curve No. 1 is commercial acid. This is a hard steel tank.

Q. No. 3? A. Yes; with no lead plate. Curve No. 2 is commercial acid plus arsenic trioxide. In the same tank. No lead plate. Curve No. 3 is commercial—

The Court: In other words, that is the patent? A. Yes.

The Court: All right. A. Curve No. 3 is commercial acid plus lead plate, connected up to twenty-four hours, and then the lead plate disconnected, but the tank not cleaned.

The Court: Ran straight on for a little while, they would have got rid of what was on the walls and then up they went. A. Yes. Curve No. 4, commercial acid plus lead plate, and at the end of twenty-four hours the lead plate was disconnected and the tank cleaned. Curve No. 5 is commercial acid plus Tergitol with lead plate connected for twenty-four hours. At the end of twenty-four hours the tank was not cleaned after the lead plate was disconnected.

Mr. Wiles: How was the tank cleaned? A. As I stated before, it was suspended in boiling sulphuric acid and then at frequent intervals they would raise the tank out and scrape it with a wire brush, and then at the end when it was taken out of the sulphuric acid it was lowered into boiling water and rinsed and then was rinsed with hydrochloric acid.

Mr. Lyon: Now, these three sheets, Exhibits 280, 281 and 282 are, in effect, a repetition of the same experiments, but using three different hard steel tanks? A. That is right.

Q. Just to show the results so that they may be seen to what extent they are consistent, using three tanks all made out of the same hard steel? A. That is right.

The Court: Like this one (indicating); have we got one of the three here? A. Yes, this is No. 1 (indicating).

The Court: The other two are not here? A. That is right.

Mr. Lyon: Now, will you turn to Exhibit 283 and ex-

Don Hathorn

plain the tests which resulted in those curves? A. This is a soft steel tank, No. 4, that we have here in the court room, and curve No. 1 is commercial acid, no lead plate. Curve No. 2 is commercial acid with no lead plate. Both of them were run for twenty-four hours. And, curve No. 3 is commercial acid plus lead plate, with the lead plate disconnected at the end of twenty-four hours and the tank not cleaned. Curve No. 4 was commercial acid plus Tergitol, plus lead plate, with the lead plate disconnected and tank cleaned after twenty-four hours. Curve No. 5 is commercial acid plus lead plate with the lead plate disconnected and tank cleaned after twenty-four hours. Curve No. 6 is commercial acid plus lead plate, plus Tergitol, with the lead plate disconnected and tank not cleaned at twenty-four hours.

Mr. Conner: Will you explain curve No. 4 with reference to curve No. 6? A. Curve No. 4 and curve No. 5 for the first twenty-four hours should be the same. They are commercial acid plus lead plate plus Tergitol. Curves 4 and 6 were run in the exact procedure, same procedure.

Mr. Conner: How do you account for that difference there, or can you? A. I can't; your explanation is as good as mine, I suppose. Curve No. 7 is commercial acid plus arsenic trioxide.

Mr. Wiles: I didn't understand which one of those had Tergitol in. A. Curve No. 4 and curve No. 5 was commercial acid plus Tergitol, plus lead plate connected for twenty-four hours. There was no difference in the materials used, or in the technique followed in curve No. 4 and curve No. 6. As far as we could tell, we carried out the exact same procedure.

Mr. Wiles: The same tank. A. The same tank, and curve No. 4, we got a much higher result than we did in curve No. 6, and I cannot account for it.

Mr. Conner: Which was first, curve 4 or curve 6? A. Curve 4 was 4/29/41; curve 6 was 4/22/41.

Mr. Wiles: Curve 6 was before the curve 4? A. Yes, a week before.

Don Hathorn

Mr. Conner: What did you do with that tank in between the time you ran the data as plotted on curve 7 and the time you ran the test as reflected on curve 4, what did you do in between those two tests? A. You mean what other curves I ran?

Mr. Conner: That, and what else did you do to the tank, if anything? A. Just cleaned it.

Mr. Lyon: You don't want to know about the other experiments he was running? They are all listed on this index.

Mr. Owen: In between those two dates, I would like to have the experiments pointed out.

Mr. Lyon: On this particular tank and not on the other tanks. A. As shown here, there was no other experiments run on this tank between the 22nd and the 29th. It just set idle. And then when we started to run curve No. 4 we cleaned the tank with the same procedure we had cleaned it before.

Mr. Conner: From running curve 4 as you testified and getting that value to running curve 6 as you testified and getting that value, I don't think you have got any reproducible curves there at all. A. Neither do I.

Mr. Lyon: You don't think you can make them, either? A. No.

Q. Now, will you turn over to Exhibit 284. Explain the tests which are graphically shown on that exhibit. A. This is soft steel tank No. 5; curve No. 1 is commercial acid plus Tergitol with no lead plate. Curve 2 and curve 4 are commercial acid—two duplicate runs without Tergitol, without the lead plate. And curve No. 3 and curve No. 7 was commercial acid plus lead plate plus Tergitol. For the first twenty-four hours they should be the same.

At the end of twenty-four hours, curve No. 7, the lead plate was disconnected and tank cleaned, while in curve No. 3 at the end of twenty-four hours the lead plate was disconnected and tank not cleaned. And curve No. 5 was commercial acid plus lead plate, and at the end of twenty-four hours the lead plate was disconnected and tank not cleaned.

Curve No. 6 was commercial acid plus lead plate, which was the same for the first twenty-four hours as curve No. 5, run in exactly the same procedure. At the end of twenty-four hours the lead plate was disconnected and tank cleaned. Curve No. 8 is commercial acid plus arsenic trioxide.

Mr. Owen: Is that the little short one? A. Yes.

Mr. Lyon: That was run for twenty-four hours? A. Twenty-four hours.

Mr. Owen: And how much arsenic trioxide did you put in that? A. One per cent.

Mr. Babecek: I think the witness made a slight error there, comparing curves 5 and 6. In one you had Tergitol and the other you didn't, did you not? A. No. The first had "Tergitol" there, but it is crossed out.

Mr. Conner: Shouldn't be there; is that correct? A. Shouldn't be there. "Tergitol" shouldn't be there.

Q. (By Mr. Lyon): Now, will you turn to the next sheet, and explain the tests that are graphically reported on this sheet. This is back again to a hard steel tank now? A. Hard steel tank No. 1. With sheets Nos. 6 and 7, we ran those after we had received the answer to the last set of interrogatories, where the plaintiff claimed copper as an inhibitor. Curve No. 1 is commercial acid, plus iron, lead, and copper added in the same amounts as claimed to be the analysis of the acid from the Zahn well. Curve No. 2 was commercial acid—I mean, C. P. acid, plus copper, the same amount, 3.1 parts per million. Curve No. 3 was the C. P. acid by itself. Curve No. 4 was C. P. acid plus lead, in the same amount as used in the Zahn well. Curve No. 5 was commercial acid without lead, and without anything added.

Mr. Allen Owen: That compares then with curve No. 3? A. No. Curve No. 3 is C. P. acid, chemically pure acid. Curve No. 5 is commercial acid.

Mr. Owen: What was curve No. 1? A. Curve No. 1 is C. P. acid, plus iron, plus lead, plus copper added in the same amounts as disclosed in the Zahn well, the acid used in the Zahn well.

Don Hathorn

Mr. Lyon: Have you explained all of these curves? What about No. 5 down there? A. No. 5 is commercial acid. No. 6 is commercial acid plus iron plus lead plus copper added in the same amounts as used in the acid in the Zahn well; the same amounts were added as in curve No. 1.

Q. Then the difference between curve No. 1 and curve No. 6, although those are duplicate experiments, or parallel experiments—or are they? A. All except that in curve No. 1 chemically pure acid was used, and in No. 6 commercial acid was used.

Q. Let us turn over to the next exhibit, 286. This is back again to the soft steel tank No. 4? A. Yes.

Q. What number is that soft steel tank? A. No. 4 is the one that we have here in the court room.

Q. These tests were made on the tank that is here in the court room? A. Yes.

Mr. Owen: What was the tank used in 285, was that hard steel or soft? A. That was hard steel, tank No. 1.

Q. All right, now will you explain these tests on which these curves were based? A. Curve No. 1, commercially pure acid plus lead.

Q. How much lead? Tell us the amount. A. The same amount that was given in the analysis on the Zahn well.

Q. The plaintiff's analysis? A. Yes.

Mr. Lyon: They reported in interrogatories, Your Honor, these amounts of lead, copper and iron which they found in these tank samples they took on these various wells, and they gave us that data.

The Court: And the witness prepared it synthetically the same as they did?

Mr. Lyon: That is right. I just want to see the date it was.

Mr. Babcock: The second day of June, 1941.

Mr. Lyon: That was June 2, 1941. That is the first time any of us had any idea, any suspicion, or hint they were going to claim there was copper in this system.

Don Hathorn

Q. And you made these experiments on 286 after we received that information as shown by Exhibit 285? A. They were made in June and July, Your Honor.

Q. Now, will you explain 286? A. Curve No. 2 is commercially pure acid with no iron, lead or copper or anything. Curve No. 3 is commercial acid as is used by the defendant. Curve No. 4 is a chemically pure acid plus copper, the same amount as given by the analysis in the Zahn well. Curve No. 5 is chemically pure acid plus lead, iron and copper in the same amounts used in the Zahn well. Curve No. 6 is commercial acid plus iron, lead and copper, the same amount as that used in the Zahn well.

Q. Now, just for a brief explanation of all these sheets of these curves, wherever the curve tends to go up more nearly as a vertical line, that means a higher rate of corrosion? A. Yes.

Q. And wherever it tends to lay down on a horizontal line, that means a lower rate of corrosion, isn't that right? A. That is right.

CROSS EXAMINATION

By Mr. Owen:

Q. Did you include in these charts, Exhibits 280 to 286, all the test runs that were made in these tanks that you have produced in evidence, and also all those which were run in duplicates of those tanks? A. No, I didn't; there are some curves at the first where I didn't pay any note to the tank number. I first started out with tank No. 1 and then I used another tank. When I started on tank No. 2 I didn't have the tanks numbered, and there was some there that I couldn't tell on which tank they were run, and they were left out. However, I think they will correspond to the curves that are shown. And then there are some others that were run using Petrowet instead of Tergitol, and there are one or two there with the C. P. acid where, after 24 hours, say I had been running lead in the C. P. acid, well, after 24 hours I would just put the same amount

Don Hathorn

of copper that was used in the Zahn well in the same solution and run it some more to see if it changed it any. That was just a preliminary experiment.

Q. That is not included? A. It is all in the data book, but it is not—all of it isn't in the curves on the curve sheets.

Q. Your data books contain every test that you ran? A. That is right.

Q. With any of these tanks? A. That is right.

Q. Now, how many of these hard steel and soft steel tanks did you make a test of? A. We had three hard steel tanks, that was tanks Nos. 1, 2 and 3; and two soft steel tanks, tanks Nos. 4 and 5.

Q. Were they all made at the same time? A. Yes—no, not all at the same time. Tank No. 1 was made first.

Q. That is of the hard steel? A. That is a hard steel tank. Then tank No. 2 next; and then tank No. 3. I can tell you when all of them were completed, when we had all five of them made. You can tell by the date of the test in here, when the tank was first run (indicating).

Q. How much time elapsed between the making of these different tanks? A. Tank No. 1 was made on or shortly before February 24th.

Q. Where did the material come from for that tank? A. It came from the same stock, from the sheet metal that was in stock that the defendant's tanks was made of, and this was cut out of a sheet of that.

Q. You mean your defendant's truck tanks? A. Yes.

Q. You make your own truck tanks, do you not? A. No, the Duncan Tank & Welding Company makes the truck tanks.

Q. Who puts the lead plates in them? A. We put the lead plates in. In getting the steel that I used for making these tanks I went to the Duncan Tank & Welding Company and told them what size tanks I wanted made up. I told them that I wanted them made up of the same steel, the same procedure in welding as we used in our truck tanks.

Don Hathorn

Q. Who determined the size of these exhibit tanks, and the shape of them? A. As I recall, Mr. Clason and Mr. Babcock and I had a conference, and decided what size tanks we would use.

Q. How many gallons do they hold? A. 11.4, I believe it is.

Q. How much acid did you put in each tank in each test? A. That was the amount of acid that we put in, which left the acid about half an inch, between a half and three-quarters of an inch from the top of the tank. We used the same amount of acid in each test.

Q. When did you make the second tank? A. The second tank was made about March 10, 1941. All this is in 1941. The first tank was made on or shortly before February 24th. The second one was March 10, in the neighborhood of March 10. I don't know whether it was on, before or after.

Q. And you told them you wanted the same thing? A. Yes.

Q. When was the third made? A. The third was made on or shortly before March 19. That is the first test that I have recorded for that tank, and it was made shortly before that. Both of the soft steel tanks Nos. 4 and 5 were made at the same time and at the same place and it was on or about April 2nd.

Q. Did you tell them how they were to be made? A. I told them to make them all out of the same material, what I mean is the soft steel tanks, out of well casing, 16-inch well casing.

Q. And the bottoms of all these tanks were welded in, were they not? A. Yes.

Q. Have you any analysis of this steel, either the hard steel or the soft steel? A. No, I do not.

Q. Now, you stated that you bought commercial acid from the Grasselli Chemical Company in carboys for use in these tests? A. Yes.

Q. And did you use more than one batch of—or more than one purchase? A. Of carboys, yes.

Don Hathorn

Q. How many? A. First we—the first order, we did not think we would run so many experiments, and, as I recall, we ordered about six or eight carboys, and then after we ran those we saw we were going to have to run some more experiments, and the last order, I believe, was for fifteen carboys.

Q. Do you know whether those came from the Cleveland plant of the Grasselli Chemical Company? A. No; I don't.

Mr. Clason: I don't exactly know the source, but I understand most of their acid is made up there.

Mr. Owen: Now, in this cleaning operation which you described, you stated that you used sulphuric acid. A. Yes.

Q. Where did you get that? A. I don't know where it came from. I got it—we have a plating shop, and they keep a sulphuric acid bath there. A plating shop.

Mr. Lyon: They have sulphuric acid they use in that plating shop? A. Yes.

Mr. Lyon: You went over there and got some of that? A. Went over and used the sulphuric acid bath to clean the tanks.

Mr. Owen: Did you dip it out of the acid bath, for the purpose, that is, out of the pickling bath? A. No.

Q. Did you get it yourself? A. No. Put the tanks in the sulphuric acid bath.

Q. Just as though you were pickling them; is that right? A. I don't know whether you would call it pickling or not.

Q. You submerged these tanks in that pickling bath, did you? A. Yes, in the sulphuric acid.

Q. Now, what do you use that tank for? A. Cleaning surfaces of metal.

Q. For getting them ready for plating? A. Yes.

Q. And how long did you leave these tanks in that pickling bath? A. Well, it ranged from about forty-five minutes to an hour.

Q. That was boiling? A. Yes.

Q. And what did you do after you took the tanks out

Don Hathorn

of the pickling bath? A. We rinsed them in hot water, and then we rinsed them with hydrochloric acid.

Q. What strength of hydrochloric acid? A. Fifteen per cent.

Q. You poured some hydrochloric acid in the tanks and sloshed it around, is that what you mean? A. Well, we rinsed them by just pouring hydrochloric acid in.

Q. Filling the tank and then— A. (interposing): We didn't fill the tank.

Q. How much did you put in? A. We put in about a gallon.

Q. Was that this same hydrochloric acid you were using in these tests? A. Yes.

Q. Poured out fresh acid from the carboys? A. Yes—no, we diluted it, of course.

Q. You diluted it to fifteen per cent? A. Yes.

Q. Now, who prescribed this cleaning operation? A. George Mahlin there in the laboratory.

Q. Who is he? A. He is the chemist in the Halliburton laboratory.

Q. Do you know what that pickling bath contained? A. Sulphuric acid.

Q. Anything else that you know? A. That is all that I know of.

Q. You don't know the composition of that sulphuric acid, do you? A. It was ten per cent, as I recall.

Q. How did you get that information? A. That is what Mr. Clason told me.

Q. That is, Mr. Clason told you that the pickling bath was a ten per cent sulphuric acid; is that right? A. Yes, sir.

Q. Do you recall what kind of tank that was in? A. It was in a steel tank, as I recall.

Q. You don't know whether it had any other ingredients in it besides that sulphuric acid? A. No, I don't.

Q. You have no sample of it? A. No.

Q. You never had a sample of it analyzed? A. No.

Q. Do you recall whether that pickling tank was unlined or lined? A. I wouldn't know whether it was or not.

Don Hathorn

Mr. Lyon: All these tanks were put in that same bath in the different operations in cleaning the tanks, weren't they, so whatever the bath did to the tanks it did to all the tanks each time they were cleaned? A. Yes, with the exception of about the first two or three that we didn't put in the sulphuric acid bath. Then we decided we would put them in there so they would all be cleaned in the same procedure.

The Court: Those are in your notes but not on the curves? A. Yes.

Mr. Owen: Now, these cleaning operations took place at different dates over a period of how many months? A. The first test was run from February 24th until about the first of July, I believe.

Q. And whenever you finished a test with one of these tanks, it was taken out and put through this cleaning procedure which you have explained? A. Yes.

Q. That is, you didn't wait and accumulate a lot of these tanks and take them out at the same time? They were cleaned promptly after the test? A. They were cleaned promptly before the test.

Q. So that the dates of the tests would indicate approximately when the tanks were cleaned? A. That is right. They were cleaned immediately before the test.

Q. Was this pickling tank being used in the regular commercial pickling operations during all that period? A. Yes, I suppose it was.

Mr. Lyon: I don't think the witness said that that was a pickling tank, Your Honor. I think that is being injected. I think he should be asked—

Mr. Owen (interposing): What was it? A. A bath of boiling sulphuric acid.

Q. What did they use it for? A. For cleaning metal.

Q. What did they do with the metal after it was cleaned? A. After the metal is cleaned then they plate it.

Q. Did you ever run any corrosion tests in one of defendant's commercial truck tanks? A. You mean the large size truck?

Don Hathorn

Q. The one that they use in delivering acid from the storage stations to the wells for acidizing operations? A. No.

Q. You had plenty of them around there at Duncan, didn't you? A. Well, there are some there, yes.

Q. Some there all the time? A. They are being made, shipped out all the time.

Q. But you never ran any test in one of those tanks? A. No, I haven't.

Q. The tanks when they are made by this Duncan Tank & Welding Company, they are delivered then to the Halliburton Company at its plant in Duncan, is that right? A. Yes.

Q. And then the Halliburton Company puts in these lead plates? A. Yes.

Q. And does the Halliburton Company also give what is called a polarizing treatment to the tanks before they leave Duncan? A. Most of them are before they leave Duncan.

Q. So that you have there in Duncan these tanks which the company uses in delivering acid from the storage stations to oil wells, both before they have been equipped with these lead plates and after they have been equipped with them, and after they have been polarized? A. Yes.

Q. As I understand it, the only tests that you made were on these cylindrical tanks which you have produced, or others made in accordance with them? A. Yes, sir.

Q. In some of these tests you stated that you added copper, lead and iron? A. Yes.

Q. Do you know in what form those metals were added? A. In the form of chlorides.

Q. Did you make the additions yourself? A. Yes, sir.

Q. You had the materials furnished to you by whom? A. They were in stock there in the laboratory.

Q. You weighed them out, the amounts that were to be put in these different acid baths? A. I did not weigh them. I made the calculations.

Q. What do you mean by that? A. I made the cal-

Don Hathorn

culations of how much weight was to be used, and one of my assistants weighed it out.

Q. Who put them in? A. As I recall it, I put in part of them, and part of them were put in by my assistants.

Q. Did you analyze the solutions either before or after you made these metallic additions? A. Not for the copper and lead; I just analyzed them for iron.

Q. Did you analyze them for any purpose? A. I just analyzed them for iron. We took a sample after we made up our solution, for our initial iron content.

Q. That was the only analysis that you made? A. That is right.

Q. You would take samples of the acid out from time to time and analyze them for iron? A. That is right, yes, sir.

Q. When you removed these lead plates by cutting them off and suspending them from another standard, as indicated in curves 4, 5 and 6 of Exhibit 280, who did that work, and where was it done?

Mr. Lyon: I don't think that is what he said he did, Mr. Owen.

Q. Then he can tell us what he did. A. The lead plates were not removed from the solution. They were just cut with a pair of tin snips, and the stand—the clamp on the stand was clamped to the lead plate, and the lead plate was left suspended in the solution all the time.

Q. And submerged to the same extent that it had been before? A. That is right.

Q. Who did that work of disconnecting the lead plate and resuspending it? A. Well, I did part of it, and of course I would have to have an assistant there to help me. There was generally two of us that cut the lead plate and clamped it.

Q. How did you cut it? A. With a pair of snips, tin snips.

Q. And how long did that operation take? A. Well, I would say about a minute; all you would have to do was to cut your lead plate.

Don Hathorn

Q. It wouldn't take any great length of time? A. No, it wouldn't take any great length of time.

Q. Now, referring to Exhibit 280, the first run indicated on that exhibit is the No. 5, is it not? A. You mean first in date? That is right.

Q. And the No. 6 run is the second in date? A. Yes.

Q. And the No. 3 run is the third in date? A. Yes.

Q. The No. 1 run is fourth? A. Yes.

Q. The No. 4 run is fifth? A. Yes.

Q. And the No. 2 run is sixth? A. Yes.

Q. Now turn to the next exhibit, 281. On that exhibit the No. 1 run was the first one, the earliest in date, was it not? A. Yes.

Q. And then the next one to be run was No. 4 on the exhibit, the next one is No. 2 on the exhibit, the next one is No. 5 on the exhibit, and the next one is No. 3 on the exhibit? A. Yes.

Q. Now turn to Exhibit 282. The first run on the exhibit is the earliest in date? A. Yes.

Q. And the fourth one on the exhibit is the next in date, the fifth one is the third in date, the second is the fourth in date, and the third is the fifth in date? A. Yes.

Q. Now, on Exhibit 283, the third one on the exhibit is the first in date, the first one on the exhibit is the second in date, the sixth one on the exhibit is the third in date, the fourth one is the fourth in date, the last one is the fifth in date, the fifth one is the sixth in date, and the second one is the seventh in date? A. Yes.

Q. Now, on Exhibit 284, the fourth run on the exhibit is the first in date, the fifth on the exhibit is the second in date, the second on the exhibit is the third in date, the third on the exhibit is the fourth in date, the first on the exhibit is fifth in date, the seventh is the sixth in date, the sixth is the seventh in date, and the eighth is the eighth in date? A. Yes.

Q. Now, these tests shown on Exhibit 285 used the same tank as that used in the tests shown on Exhibit 280? A. Yes; that is the first sheet.

Don Hathorn

Q. And there were six runs with that tank indicated on Exhibit 280? A. Yes.

Q. So the seventh run in that tank is the fifth one on Exhibit 285; is that right? A. The seventh run in which?

Q. In that tank. You see, there were six runs in that tank before these runs indicated on Exhibit 285 were run, and I want to get the order in which all of the runs were made in that tank. So we will refer to the earliest of the runs on Exhibit 285 as the seventh run in that tank? A. Well, it is the seventh run on this chart. However, there may be some of those others that I said I couldn't distinguish which tank they were in, in this tank.

Q. I want them in the order on this chart. A. On this chart.

Q. Yes. So that the fifth run indicated on Exhibit 285 was the seventh of the runs in that same tank? A. Yes.

Q. That is, of those that are shown on any of these charts? A. Yes.

Q. And the eighth run in that tank is the third run on this exhibit, the ninth run in the tank is the first one on this exhibit, the tenth run in the tank is the fourth on this exhibit, the eleventh run in the tank is the second on this exhibit, and the twelfth run in the tank is the sixth on this exhibit? A. Yes.

Q. Now, turning to the next exhibit, 286, was that tank used before on any of these other exhibits? A. Yes, it was used on sheet No. 4, the same tank as used on sheet No. 4. That is DX-283.

Q. DX-283, sheet No. 4; there were seven runs, that is right, isn't it? A. Yes.

Q. So that the eighth run in that tank would be the third run on Exhibit 286? A. Yes.

Q. And the second on the exhibit is the ninth in the tank, the fifth on the exhibit is the tenth in the tank, the first on the exhibit is the eleventh in the tank, the fourth on the exhibit is the twelfth in the tank, and the last one on the exhibit is thirteenth in the tank? A. Yes.

Q. Have you ever conducted any other corrosion tests of any kind? A. No.

Don Hathorn

Q. These are the first and only ones? A. Yes.

Q. Who directed you in the order in which these tests were made? No one? A. No. Mr. Babcock and Mr. Clason and I—

Q. (Interposing): You discussed each test and decided what the next test would be? A. We discussed what the general procedure would be, not as to individual test. What I mean, we didn't have a conference on each run. We would pick out certain groups to run and would run those. We would discuss those, and if there was any additional runs we decided we wanted to make, we would make them.

Q. How much of a group would you run? For instance, the very first test you made, how many did you outline for the first? A. The first test outlined was to run commercial acid on a tank representing our tank in the field, not using a lead plate; and then to run an experiment using the lead plate. That was all we thought at first run. After we ran that, we were curious and ran other experiments. We also agreed to use arsenate trioxide and Tergitol in that first set of runs.

Q. Well, now, will you point on this Exhibit 280 which tests were decided upon at the first conference before any of them were run? A. I probably could tell you better from this data book. We decided to run experiments shown as Curve 5, Sheet 1, and the one shown as Curve 6 on sheet 1. And the one shown as Curve 1 on Sheet 1. And I believe that was all on the first run. I don't know whether I could distinguish exactly which runs were run before we had another meeting.

Q. Well, I call your attention to the fact that the third curve on sheet 1 was run before the first one. A. Well, they are both the same runs. What I mean, they were run in exactly the same way. Both would be covered.

Q. Oh, 1 and 3 were run in the same tank? A. Yes, sir. We decided to run commercial acid in our tank, the commercial acid plus our lead plate, and commercial acid plus Tergitol plus lead plate, and commercial acid plus Tergitol, as I recall, in the first.

Don Hathorn

Q. Now, will your notebook show what your next plan was after those first runs were made? I suppose you had a consultation again. A. Then we decided to run some experiments using arsenic trioxide and Petro-Wet, and then run experiments where we had our lead plate connected and then disconnected and cleaning the tank after twenty-four hours, and after we had run those, then we decided to make up another hard steel tank, making three hard steel tanks and two soft steel tanks to duplicate the casing in the well, and run all of those using commercial acid and commercial acid plus our lead plate where the tank was cleaned and not cleaned after twenty-four hours. And the commercial acid plus Tergitol, and the commercial acid plus arsenic trioxide.

Q. Now, can you tell about when that conference was had? A. It was shortly before March the 31st, 1941.

Q. Well, then you proceeded to have these other tanks made up, did you? A. Yes.

Q. Then started in another series of tests? A. Yes.

Q. Now, can you point out, without giving the order in which they were made, the tests that were conducted in accordance with the plan laid out at that conference late in March? You have already given the order in which they were run. I just want to know which of these groups were run in accordance with that conference. A. Well, all of them are dated after that time.

Q. Then all of them dated later than March 31 were run in accordance with the plan made at that time? A. Yes—well, except that there are other plans where we used the ingredients of the Zahn well, that was made after we received our answer to the second set of interrogatories.

Q. Which of these groups would that be? A. Well, those were all made after June 10, on or after.

Q. Now, as to the order in which this second set of tests was run—I mean the large group that you ran after the second conference. Did you consult either Mr. Clason or Mr. Babcock as to the order in which those tests were run? A. No.

Den Hathorn

Q. That was left entirely to your judgment? A. Yes.

Q. Did you know what you were trying to show by those tests? A. We wanted to show what the lead, what kind of protection our lead plate gave, compared with commercial acid without any lead plate.

Q. You knew that you wanted to make a good showing for the lead plate, is that right? A. Sure.

The Court: When it was connected, you mean? A. Yes, sir.

The Court (to Mr. Owen): You meant to include that in your question, the lead plate when it was connected? You meant that, Mr. Owen—you meant to include that in your question?

Mr. Owen: Well, I did not ask that question.

The Court: When you said you wanted to make a good showing for the lead plate, you meant when it was hitched up?

Mr. Owen: Oh, yes, when it was hooked up to the steel tank, that is right. A. Yes.

The Court: In other words, that is their claim that—

Mr. Owen: Oh, yes.

The Court: And when it is disconnected, that is out. That was the way I understood it. Here is one question that occurred to me that I wanted to ask you, witness. In your effort to get the proportion of the steel exposed to the acid, and the amount of lead exposed to the acid, you tried to get that comparable to the steel and the lead of your transportation tank? A. That is right.

The Court: And did you take into account the fact that you, for instance, as to the iron, that you were not going to fill it within—the condition in your tanks too, I suppose, your transportation tanks, are they filled clear to the very tip-top? A. No, they are not.

The Court: And here of course this wasn't filled to the tip-top (indicating), and here is some of the lead, you took that into account, that this part over outside here of course wasn't going to touch it? A. That wasn't included.

The Court: You didn't include that, and the same

Don Hathorn

way for it a little ways down, for the lead here (indicating), was true of the iron to the lead, that the acid wouldn't reach all of the lead you would use? A. Yes.

The Court: But you took that into account as best you could? A. Yes.

The Court: To make the two comparable, and you have got your figures in there as to that haven't you? A. I don't know whether I have the figures—

The Court: That is what you tried to do and you have shown us right here, anybody that wants to see it can? A. Yes.

The Court: But you did take that into account, that all of this lead outside of the iron tank— A. It wasn't calculated in, included in the calculation.

The Court: All right.

Mr. Owen: Did you consider putting the lead plate on the bottom of these tanks as it is in the transportation tanks used by the Halliburton Company? A. No, we didn't; we used it this way so we would be able to disconnect the lead plate easily without emptying the acid from the container.

Q. It would have been possible to put the lead plate on the bottom so as to make your tanks more nearly resemble the transportation tanks, wouldn't it? A. Yes, we could have, but when we disconnected the lead plate we would have had to empty the acid and it would have required more time.

Q. Referring to page 121 of DX-277, I find at the bottom of the page this note, "Lead plate was copper-colored at end of run." Can you tell me who made that note, and what it means? A. I made this note, and on this particular run—as you notice, we ran quite a few tests before this, and the motor, like you see here in the courtroom, was beginning to corrode; and after a run had started, we decided that we would provide some means of protecting this motor from the fumes; so we cut a piece of inner tube, and tied it around the motor with copper wire; and after we had stopped the run, and poured the acid out

Don Hathorn

of the tank, we noticed that the lead plate was copper-colored, very muchly.

Q. Was that copper wire in the acid? A. We do not know. We had already poured the acid out. We don't know whether there was any fragments left in, or not, or whether they had all been dissolved; but since it was the only one with the lead plate that was copper colored, we presumed that there was a chance for error there, that we might have dropped some of this copper wire in there.

Q. Do you know whether the copper wire that you used in tying this rubber around the motor was immersed in the acid, or any portion of it? A. No, it was not, unless it dropped in.

Q. It was up where it would be contacted by the fumes of the acid? A. Yes, sir.

Q. Which run is that on these charts? A. So for that reason we did not plot it on the charts, because we thought there was a chance for error in that.

Q. Where did that come in connection with the runs on the charts? A. It would be on the chart, sheet 2 (DX-281).

Q. In the order of the running of the runs, where would it have come on this chart? A. It would be between runs 2 and 3.

Q. You mean it was made after run 2, and before run 3? A. Oh, you are talking about the time? This test was run May 6, 1941.

Q. What did that run have in it, anything, in the acid? A. It had lead plate and Tergitol.

Q. Had it been plotted on this chart, Exhibit 281, the line would have passed through there? A. Yes, there were 82 ounces per 1000 gallons at the end of 24 hours (indicating).

Q. Is that where I have made this pencil mark, the little circle? A. Yes.

Q. If you will turn to page 130 of that notebook, at the bottom of the sheet there appears this entry: "At 9 o'clock next morning when emptied the tank was copper

Don Hathorn

coated and the lead plate was white (probably PbCl_2).” Did you make that entry? A. No, I didn’t. Francis Anderson made it, I believe; it looks like his handwriting.

Q. Do you know any more about it than what appears in the entry? A. No, I don’t.

Q. What run is represented by that sheet on the chart? A. That is test “T,” a continuation of test “S,” which was C. P. acid, which contained iron, lead and copper in the same proportion as that found in the Zahn well, and after 24 hours of test “S” we put a lead plate in the solution and connected it to the tank, which was called “Test ‘T,’” and after we had left the lead plate there and continued that run, when we removed the lead plate there was some copper coating on the iron tank and the lead plate was white.

Q. Now, will you point out on your chart which one represents Test “S” and which one represents Test “T”? A. I don’t have Test “T” on this; I have Test “S” on the chart.

Q. Where would test “T” have come in the order of time on these charts? A. That was run for $13\frac{1}{3}$ hours, and in order to compare it with these, the initial value was already 490 ounces of iron per thousand gallons—in order to compare it with these I will have to subtract this last value from the original value.

Q. You mean your solution tested 490 ounces of iron per thousand gallons when test “T” was started? A. Yes.

Q. Then how much did it test when test “T” was concluded? A. 511, which would be a difference of 21 ounces per thousand gallons.

Q. Then where we have mentioned parts per million we should have said ounces per thousand gallons all the way through? A. Yes. At the end of $13\frac{1}{2}$ hours, 21 ounces per thousand gallons.

Q. Is that the right sheet (Sheet 1) where this test would have come in? A. It was a C. P. acid but we have no values with the C. P. acid run with lead plate to compare this with.

Don Hathorn

Q. Well, I asked you to point out on the chart the point where this test would have come in the order of time had you recorded it on the chart. Will you do that? A. Well, in that case it would have been recorded—these are not made according to the time when they were run. They were made according to tank. It would have been either recorded here on PX-280 with the other lead plates and indicated as C. P. acid.

The Court: In other words, you haven't any chart it would go on unless you made a new chart? A. Yes.

Q. Well, will you point out where your test is on these charts? A. This is sheet No. 6. Test S is curve 1 on sheet 6 (DX-285).

Q. Now this test T as I understand, was run in the same tank and immediately following Test S, is that right?

A. That is right. When we ran tests the corrosion was at this rate (witness indicating). When we put our lead plate in, connected it, at the end of $13\frac{1}{2}$ hours our lead plate had given this amount of percentage as compared with the C. P. acid without the lead plate. (Witness putting dot on chart.)

Q. When you say this amount of percentage you have indicated? A. The end of $13\frac{1}{2}$ hours the corrosion had increased 21 parts per million.

Q. And that is indicated where I make the pencil mark, circle, or dot on PX-285 (counsel putting dot on chart). A. Yes.

Q. Now, I want to get this perfectly clear. Your test S had what in the acid? A. It was C. P. acid plus iron, lead and copper added in the same proportions as used in the Zahn well.

Q. And then your Test T which followed immediately after Test S used the same acid but added the lead plate?

A. Lead plate connected.

Q. And you used the same acid that had been used in Test S? A. That is right.

Q. Without changing the acid. A. Yes. It was cleaned. Yes.

Don Hathorn

Q. You poured the acid out of the tank and added the lead plate, and then poured the acid back into the tank, same acid? A. That is right.

Q. And the introduction of the lead plate reduced the rate of corrosion from—what is it up here? From about what? A. From about 322 down to about 21 ounces per thousand gallons.

The Court: But this, as I understand it, means it was not all due to the lead plate?

Mr. Owen: That is true.

The Court: That is right, isn't it, because the lead—this other— A. (Interposing): Well, the amount without the lead plate was 322.

The Court: Yes. A. When you added the lead plate, it brought it down to 21.

The Court: But it wasn't raw acid which you put the lead plate in? A. No.

The Court: So I can't give the credit to the lead? A. No, you can't.

The Court: In other words, as I understand it, your acid has brought it down to a point about here where my—

Mr. Lyon (interposing): Oh, no. A. Oh, no. Raw acid.

The Court: Raw acid. Then you put in these other ingredients? A. No; this is the same acid. It ate this much, and then we added the lead plate and it only ate this much (indicating on the exhibit).

The Court: That is the lead plate? A. Yes.

The Court: And this is the acid. These others don't enter into it at all? A. Don't enter into it at all.

The Court: What I said was wrong, as I understand it now. The lead plate, if that experiment was correct and I read the results, would do all the work of bringing it from the raw acid to there.

Mr. Owen: Oh, yes; the lead plate was the only thing added.

The Court: I thought he—I couldn't see why, but I got the erroneous notion that you had put that acid in, let

Don Hathorn

it work, or put those ingredients in and let it work, and it brought it down to there, and then you cleaned the tank and put those same old ingredients in, what had been used back in there again with the lead plate? A. No.

The Court: I was wrong. A. Yes. It was this acid here (indicating).

Mr. Owen: Now, as I understand you, in your test S which is No. 1 on PX-285, your rate of corrosion at the end of thirteen and a half hours is shown. A. Yes.

Q. At the end of thirteen and a half hours, in test S, your acid had how much iron? A. I believe I said 322 a while ago. But it is 332 ounces per thousand gallons.

Q. Then you continued that run how long? A. Twenty-four hours.

Q. And at the end of twenty-four hours how much iron did the acid have? A. It had 545 ounces of iron per thousand gallons.

Q. Then you poured that acid out, at the conclusion of run S, scrubbed out the tank as you have previously explained, that is by the boiling of it or putting it into this pickling bath, and letting it stay there for an hour in the boiling acid, and then removing and scrubbing it out with a wire brush and rinsing it with hydrochloric acid; is that right? A. That is right.

Q. Then you poured the same acid back into the same tank and put the lead plate in it?

The Court: Now, by the "same" you don't mean this old acid that he used? A. Yes.

The Court: You mean the new acid? A. No, the same acid.

Q. (By Mr. Owen): The same acid. You poured the same acid back?

The Court: As used in the run shown by curve 1? A. Yes. We removed the acid from the tank, cleaned the tank, connected the lead plate and then poured the acid back into the tank.

The Court: All right, now. Not fresh acid? A. No.

Mr. Lyon: Those different runs on these sheets used different acids.

Don Hathorn

The Court: I don't see how I am going to compare these when you are through, because this acid--this isn't this acid, this isn't this acid the way--when you start on this curve, it isn't the same condition it was in when it started on that curve. A. No.

The Court: All right.

Q. (By Mr. Owen): The acid that has been removed—that has been used in run S, was removed from the tank, the tank then subjected to this cleaning treatment, and the same acid was returned to the same tank; that is right? A. Yes.

Q. And then you added the lead plate to that tank, which acid had been in the test S? A. Yes.

Q. And then you ran it for thirteen and a half hours, and you found how much iron in the acid at the end of that time? A. At the end of that time, the total iron content was 565.5 ounces per thousand gallons.

Q. And then you—you say your added iron in that thirteen and a half hours would have been how much? A. 20.5 ounces per thousand gallons.

Q. So that after it had in all of the iron that was taken up in test S, it ran for thirteen and a half more hours after the cleaning operation and took up how much more iron? You just gave it to me. What was it? A. 20.5 ounces per thousand gallons.

Q. Now, at thirteen and a half hours, at the end of run S, how much iron did the acid eat up? A. 332 ounces per thousand gallons.

Q. That is in the thirteen and a half hours. The last thirteen and a half hours, I want. Of test S? A. May I have my calculation book? (After calculating): In the last 13½ hours of test S, the acid ate 217 ounces per thousand gallons.

Mr. Lyon: I would like to suggest to Your Honor that we don't know unless somebody asks at this point in the record, we won't know when he put the lead plate in whether it was bonded to the steel or not. Sometimes, as I understand it, they have the lead plate in without connect-

Don Hathorn

ing it to the steel, and sometimes they had them connected to the steel, and the record does not show now whether it was connected to the steel or not.

Mr. Owen: Is that your book? A. Yes.

Mr. Owen: I will ask him.

Mr. Owen: Was that lead plate bonded to the steel in your test T? A. It was.

Q. You didn't try a similar test to see what it would have been had it not been bonded to the steel? A. No, I didn't.

Q. At the end of test S, did you look at the walls of the tank to see whether or not it was coated with copper? A. I do not recall. It is not recorded.

Q. But you did notice at the end of test T, the walls of the tank were coated with copper? A. That is recorded here. I did not notice it myself.

Q. You did not make that note? A. No.

Q. On page 122 of this same notebook, there is an entry at the bottom, "Acid was black with suspended matter at end of this run." Did you write that on there, Mr. Hathorn? A. No, sir, I did not.

Q. Well, who did? A. I could not say.

Q. Have you got any explanation for it? A. No, sir, I have not.

Q. Will you point out on the charts which run that is? A. (Indicating): Here. This is DX-283, sheet No. 4, curve No. 5.

Q. That is the test that appears on page 122 of your notebook? A. Yes, sir.

Q. What was in that acid, anything? A. Commercial acid, plus lead plate.

Q. Anything else? A. With the lead plate removed and tank cleaned at the end of 24 hours. This was in soft steel tank No. 4 (indicating).

Q. Was it continued after the 24 hours? A. Yes, sir. The lead plate was removed, the tank was cleaned, and continued for an additional 24 hours.

Q. And then this note at the bottom of the sheet that

Don Hathorn

the acid was black with suspended matter at the end of this run refers to the end of 24 hours, or the end of the extended run? A. I would presume that it was at the end of 24 hours, because it is written under the—at the end of the first 24 hours.

Q. When the run was continued, was it continued with the same acid? A. Yes, sir.

Q. Have you any idea what that black suspended matter was? A. No, sir.

Q. Now, on page 127 of this same notebook there is a note, "No stirring since 8 8 8." Will you explain what that means? A. This is in plain commercial hydrochloric acid, with no lead plate, in hard steel tank No. 1; and after 24 hours we shut the motor off and allowed the acid to remain in the tank without being stirred from 1:30 P.M. to 9 A. M.

Q. Which run is that, and which chart? A. This is not in the chart. There was no agitation. We do not have any on the charts without any agitation.

Q. In the test reported on page 129 of this same notebook, the statement is made that iron, lead and copper were added to one crock. What were those crocks? A. Well, they were five-gallon crocks. Just ordinary five-gallon crocks used to mix acid in.

Q. Do you know how much copper, lead and iron was added to that acid in the test on page 129? A. The same amount as used in the Zahn well.

Q. The amounts are not indicated on this page, are they? A. No.

Q. Where are they indicated? A. I have the calculations. I believe they are indicated in the other book, the data book. There were added 380 parts per million of iron, 435 parts per million of lead, 3.1 parts per million of copper, this is by weight.

Q. Now, how do you connect that entry up with the entry on page 129 of the other notebook?

The Court: You mean how does he identify? A. The letter "S" is the same.

Don Hathorn

Mr. Owen: Now, I believe you stated that you did not weigh out these metal additions? A. No, I did not.

Q. Did you check the weights in any way? A. No, I didn't.

Q. You don't actually know how much copper, lead and iron went into these tanks? A. Yes, if their weights were accurate, and I trust them.

Q. You mean that you simply told them to put in so much and you relied on them to do it, is that it? A. Yes; I relied on them to make the weights.

Q. There is no entry in any of these notebooks, is there, showing the weights that actually were added to the different tests? A. Yes, on page 50 of DX-278.

Q. What does that show? A. Iron chloride was 85.7 grams, lead chloride 27.1 grams, copper chloride .387 grams.

Q. And that is what metals were added to test "S," is that right? A. In tanks Nos. 1, 2 and 3, and in soft steel tank No. 4—I mean iron chloride 88.5 grams, lead chloride 28 grams, copper chloride .398 grams.

Q. And you have only one indication of weights for tanks 1, 2 and 3, that is right, isn't it? A. Yes.

Q. You assume that those exact amounts were placed in each of those tanks? A. Yes.

Q. Now, when you cleaned these tanks after a run, how did you suspend them in the sulphuric acid pickling tank? A. They were suspended by clamping them to an electrical bus bar running over the sulphuric acid bath which was connected to electric current for making them the anode in the tank.

Q. What metal was that bar made of? A. I suppose it was made of copper, most bus bars are.

Q. Will you explain just how the tank was clamped to that copper bar? A. By a steel hook. A steel hook was hooked to the handle of the tank and then hooked onto the copper bus bar, allowing the tank to be suspended in the acid.

Q. How high above the top of the acid is this bus bar? A. It would be a guess. I would say about six or eight inches at least.

Don Hathorn

Q. Did it run across the pickling tank parallel with the surface of the solution? A. Yes.

Q. About six or eight inches above? A. I wouldn't say exactly six or eight inches but close to that.

Q. How far was the top of your tank from that bus bar when you hooked it onto the bus bar as you have explained? A. It was completely immersed in the solution. I would say it was at least 10 or 12 inches below the bus bar.

Q. I believe you stated what this pickling tank was used for. I haven't it in mind. Will you repeat that? A. I don't know whether you would call it a pickling tank or not, but it was used to clean the metals. We have our own plating shop. We do a lot of plating of our equipment. It is used to clean the metal surface in order to plate the iron, steel.

Q. Do you know what acid is used in that pickling tank? A. Sulphuric acid.

Q. Do you know whether any pickle control substance or acid regulator is used in that pickling tank? A. I understand there isn't.

Q. Just the straight acid, so far as you know? A. Yes.

Q. Did you ever test that acid during the time that you were cleaning tanks in it? A. No. However, since the tank was made the anode all the corrosion should have been on the tank. If there was any impurities on the tank it should have been removed since it was made the anode. This test tank was made the anode in the sulphuric acid solution so that any deposit that had been formed on the test tank would be removed electrically. That is reversing the procedure in which the tank had been coated; in our test it would be removed in exactly the opposite way.

Q. And that would remove any lead that might be on the surface, you think, of your tank? A. I would think so.

Q. How about copper? If there was any copper on the surface would that remove the copper? A. Well, if the copper was able to plate on in our test it certainly will be able to be removed in the cleaning tank.

Don Hathorn

Q. Now, did you make any test or analysis to ascertain whether or not the lead and copper were actually removed from the surfaces of your tanks by your cleaning operation? A. No, I think not.

Q. Do you know how frequently that acid was renewed in the pickling tank? A. No, I do not.

Q. Do you know whether it was ever changed? A. No, I do not.

Q. Do you know the conditions of these parts when they were placed in this pickling tank for removing the scale or whatever was removed? That is, were they dirty, had they been pickled before, how had they been handled and used? A. These tanks?

Q. No. The metal pieces which are placed in the pickling tank for the cleaning operations preparatory to cleaning. A. Most of the parts are just parts that have been machined in the shop, are taken directly from the machine shop to the plating shop.

Q. So that when they are placed in the pickling bath they are covered with oil, dirt and grease that comes from the machine shop? A. In some cases they may have some oil.

Q. After your tests that were indicated on these charts, did you analyze any of the solutions for lead, copper or other content than iron? A. No.

Q. When your tanks were put into this pickling tank, did they have the lead plates connected to them? A. You mean in the sulphuric acid?

Q. Yes. A. No.

Q. Did they have any portion of the lead plate connected to them? A. They had just a section where the lead was puddled onto the tank.

Q. That is where you sawed off the main section of the lead, the remaining part was on the bank, when you put it into the pickling solution? A. Yes, sir.

Q. And that was true in each case where the lead plate was used? A. Yes, sir.

Q. Before you used these tanks which you have de-

Don Hathorn

scribed, did you put them through any polarizing operation? A. No, sir.

Q. Do you know about a polarizing operation to which your regular transportation tanks are subjected? A. Yes, sir.

Q. But you did not do that to these? A. No.

Q. What if any check did you make on the acid that you used; did you check each carboy or each shipment, or what? A. The only check we made was when we made up our batch for the test, we made—that is, we took a sample before we put it in the tank, and analyzed it for iron content.

Q. That is the only analysis that you made? A. Yes.

Q. Will you explain just how you made the iron analyses? A. It is given in front of the calculation book, DX-279, on page 27. This is the procedure; I will read it. (Reading): "Bring to boil 10 m. l. of the acid solution; while hot, reduce ferric iron to ferrous iron with stannous chloride (using two drops excess). Dilute to 150 m. l., add 25 m. l. saturated mercuric chloride, 20 m. l. titrating fluid, 10 drops barium diphenylamine sulfonate indicator; titrate to purple end point with potassium dichromate."

Q. The dichromate solution. How much of that did you use? A. Well, you will have to refer to the—each one will be different for each titration. They are given in the data book.

Q. Will you look through that book and see if it is not true that in giving some you used less than one cubic centimeter of this titrating solution? A. I beg your pardon. If I am not mistaken, there was a factor on this titration fluid of 10.

Q. What do you mean by that? A. Where they have .0420 c.c. it was .420 used.

Q. Well, you say if you are not mistaken. Is there anything in this book to indicate that? A. I believe not.

Dr. Prutton: .420 is less than 1. A. Yes.

Mr. Owen: Well, now, in answering that question, you were referring to page 35 of DX-277? A. Yes.

Don Hathorn

Q. Now, will you explain the entries in the fourth column of the table on that page and state what you understand them to mean? Do they show the quantity of this titrating solution that was used in these different tests, or in these different analyses? A. Yes, I would say they did.

Q. And what are those? Read a few of those figures down, will you, from the top? A. Now, as I said before, there is a factor of 10.

Q. Yes. You read them and then I will bring that out. A. .0420, which would be .420 c.c. of titration fluid used.

Q. That would be your factor of 10? A. Yes. That is before the test started. That is the titration we got on the blank sample.

Q. Now, how much in ounces or in teaspoons would that .042 be? A. I think you will have to have some of the doctors figure that out. I don't know. I am not a chemist. The boys who made these titrations were chemists, all of them, and they made these entries.

Alfred Douty

ALFRED DOUTY,

a witness called on behalf of defendant, testified as follows:

DIRECT EXAMINATION

I am 42 years of age, reside at Elkins Park, a suburb of Philadelphia, Pennsylvania, and am the chief chemist of the American Chemical Paint Company of Ambler, Pennsylvania. As to my training in chemistry, I attended the University of Pennsylvania and studied chemical engineering. At the conclusion of the course I got a bachelor of science degree.

Mr. Lyon: What if any experience did you have in practicing your profession from the time you left school up to the time you became connected with your present company? A. From the autumn of 1919, the year when I graduated, until the summer of 1923, I was employed by a Philadelphia consulting engineering firm, Julian S. Simpson. The firm was engaged in general power plant consulting practice, including the study and treatment of boiler water for the prevention of scale, and also engineering problems connected with the efficiency and design of power plants. In 1923, in the summer, I became connected with the American Chemical Paint Company, at which time the main problem under investigation in the laboratory was the development of materials which were to conserve acid in the pickling of steel. I worked intensively on the inhibiting phase of the business up until about 1930. I also did work on many other products, including paints, cleaners for metal surfaces, soldering fluxes, and so forth. In 1930 I was given charge of the patent department of the company, in addition to my duties as chief chemist, and that meant that I was unable to spend as much time in the laboratory as I previously had, but since that time I have been directly in charge of the laboratory and we have had no less than one man at any time giving his full attention to the develop-

Alfred Douty

ment and study of inhibitors. Other men have been in charge of problems involving corrosion and its prevention generally.

I first started work with the American Chemical Paint Company in 1923 and have been with them ever since. I knew James H. Gravell of Elkins Park, Pennsylvania, named as the patentee in letters patent No. 1,678,775, granted July 31, 1928, which is DX-5 in this case. I knew Mr. Gravell very well. He was president and founder of the Americal Chemical Paint Company, and he was, at first, the only chemical expert the company had. As a matter of fact, I was the first chemist employed by the American Chemical Paint Company. Mr. Gravell at that time spent at least half of his time in the laboratory. He was a very brilliant man, although his formal training was not very great. And I worked beside Mr. Gravell a number of years. Of course, he had the duties of running the whole company, and he couldn't work continuously in the laboratory, whereas I did. It was not long after I had become connected with the company that we began to hire other men. But at first I worked with Mr. Gravell alone exclusively. Mr. Gravell died in December, 1939.

Q. You have said he was a very brilliant man. But I think the court would probably like to know a little more about him. It is a fact that he started this company with nothing but an idea, and what did he have that he made out of it when he died, just in a rough way, give the court an idea. A. I don't know whether it is pertinent to the issue, but in order to make clear what Mr. Gravell did, he started as an electrical engineer and he worked for the Hale & Kilburn Company in Philadelphia, who were making the early steel bodies, automobile bodies, and the early steel automobile bodies were rusting so badly under the paint that Hale & Kilburn were taking them back faster than they went out. And Gravell, in connection with a Philadelphia druggist by the name of George Feidt, conceived of an invention whereby they treated these bodies with a mixture of alcohol and phosphoric acid, which removed the

Alfred Douty

things from the surface which caused them to rust underneath the paint. And then he had—of course, he had the idea, and Gravell used to mix the things up in the morning to go out and sell them in the afternoon and they—it just happened to fill a great need, and so the company began to prosper.

Mr. Owen: How do you know all this, Mr. Douty? A. Well, I knew Mr. Gravell very intimately for about twenty years. I knew him and a great many of his friends. I have seen a good many of his records. He was a great expert on electric welding. He was an expert in the case on the Harmatta patent between Thompson Electric Welding Company and Ford Motor Company. I still have his file on that particular matter, which involves about ten large drawers of filing cards, and a number of larger drawers of data. I don't know that I know anything in life better than I know Gravell's accomplishments and mentality.

Mr. Lyon: Now, you had not finished your answer to my question. I asked you a question, that is, you told what he started with; can you give us an idea of how well he got along, and how he finished? A. Mr. Gravell will probably be best remembered by the public because, at his death, he left the entire company, which is valued at some millions, to a number of his employees, of which I am one. His company was extremely prosperous during his lifetime, and he died a very—well, I would say a moderately wealthy man at any rate. He did not leave any family. His wife had died just a year before he died, and he had no children. He had one brother.

Q. Now, when you went to work with the company in 1923, was the company interested in pickling agents, or inhibitors in any way? A. Yes, sir, it was.

Q. What was it doing that involved the use of inhibitors in acid at the time that you went to work with them? A. When I went with Mr. Gravell, he thought that he—he had been investigating agents that he had heard of that were being sold in Europe, which were said to reduce the attack of acid on steel during pickling, and to save

Alfred Douty

money; and he had investigated a number of agents, of which he had come across one which seemed to him to have promise. He felt that his training in chemistry was inadequate, and he hired me, because he felt that he needed someone of more training, to investigate systematically the field of inhibitors. And that was my first work. And I, although it was new to me, was able fairly shortly to develop techniques for preparing inhibitors, which went beyond anything that Mr. Gravelle had thought of at the time; and it was not long after I got with the company that he began to exploit a material which was known as rodine, and rodine has ever since been the generic term for the kind of inhibiting agents which we sell to the trade for various purposes.

Q. You heard the depositions read here concerning the use of an inhibitor by the Gypsy pursuant to Dr. Westcott's deposition. A statement was made by several witnesses the inhibitor used there was rodine purchased from the American Chemical Paint Company along about 1928, '29 and '30. Were you selling such a material under that name at that time? A. Yes, sir.

Q. Do you know what it was? A. Yes, I do.

Q. Was it an inhibitor for hydrochloric acid? A. Yes.

Q. What was its chemical composition, if you know?

A. It was a hydrochloric acid solution of basic materials extracted from a waste product known as bone tar oil or known to the chemists as Dippel's oil. That product was obtained by the distilling of bones—in fact, it consisted of a number of bases wherever protein material is distilled in the presence of fat. In fact, in the presence of the aldehyde acrolein. The basic materials are extracted from the tar oil by mixing them with hydrochloric acid. It then separates an upper layer of oil which is worthless and consists largely of nitriles of higher fatty acids and also a certain amount of tarry material, and there remains a clear hydrochloric acid solution which is the material that is sold as Rodine, or was originally sold as Rodine No. 2.

Q. You have read Dr. Westcott's report, which is in

Alfred Douty

evidence in this case, have you not? A. I have heard it read.

Q. And you heard what Dr. Westcott had to say in that report as to what Rodine No. 2 would do in protecting well pipe when the acid was being introduced down into the well? A. Yes, sir.

Q. Is it a fact that Rodine No. 2 would produce the result which Dr. Westcott stated in his report it would produce? A. Certainly.

Q. Now, were you aware of the making of the discovery or invention which is set forth in the patent involved in the defendant's counter-claim here, Gravell Patent 1,678,775? A. Yes, I was.

Q. You were aware of Mr. Gravell's work at the time he made that discovery and know under what circumstances it was made? A. Yes.

Q. Before I ask you to give us that history, would you take and refer to the patent itself and tell us what you understand the invention to be, covered by that patent? A. Before I can state what I consider the invention to be, I would have to give you a very brief outline of the state of the knowledge at the time Gravell made this invention, so that the terms he uses, the materials he refers to, may make some sense.

Mr. Lyon: All right.

(Witness continuing): Up to the time of Gravell, there had been a number of patents and references in the literature to substances capable of reducing the rate at which acids attack metal. The only use that had ever been made of that information, as far as I have been able to determine, was in the addition, usually, of organic substances, to the pickling baths in which scale is removed from steel, to reduce the unnecessary loss of metal. Now, scale is removed from steel—scale, by the way, is generally—I mean the oxide which is formed when steel is heated during the fabrication process prior to rolling or forging.

Now, in pickling off that scale the common agent in this country is sulphuric acid. Hydrochloric acid is used

Alfred Douty

more commonly in Europe. But, sometimes hydrochloric acid is used here. Mill scale is very resistant either to hydrochloric acid or to sulphuric acid, but it is more resistant to sulphuric acid, and the scale is not removed from the steel by being dissolved therefrom; it is removed because it is full of cracks, the acid gets down through the cracks and eats the metal out from under it, and as the metal is eating out from under it hydrogen is generated and the hydrogen gas gets in behind the scale and the scale appears to be either slid off or blown off in flakes when it sinks to the bottom of the bath.

Now, in that operation it is inevitable that some metal be dissolved. The removal of scale from steel is practically impossible to accomplish without the removal of some metal. However, scale is not generally uniform on a piece of steel; it is heavy in some spots and not so heavy in others, or it is more cracked in some spots and not so much cracked in other spots. Therefore, if you have a large piece of steel and are pickling it, the scale may be all off of one end while it is still quite firmly attached on the other, and it is necessary to protect the sound metal, which has been pickled, during the rest of the necessary period until you get the scale all off of the end on which the scale remains.

Well, with that as a preamble, and getting a sort of the state of the art at the time Gravell got into the picture with his patent. Gravell made the interesting discovery that the substance, arsenic, which had been previously mentioned as a restrainer, when used in connection with organic inhibiting materials, really organic inhibiting materials, gave a degree of protection to the metal which had not heretofore even been dreamed was possible. In other words, a degree of protection such that an iron nail, ordinary steel nail, could be put into a ten per cent sulphuric acid solution containing, let us say, a good organic inhibitor such as this solution of organic bases, plus some arsenic, and left there for months and months and months at a time without being apparently affected at all.

Now, arsenic had some great disadvantages in the

Alfred Douty

pickling of steel. Its use as an inhibitor was originally suggested by a fellow named Meurice, back in the 1880's. Meurice had a wire mill in Belgium, he was the manager; and he found that the wire seemed to be smoother and less corroded when he put arsenic in the acid than when he did not. This he discovered accidentally, because he found that he had two kinds of sulphuric acid from two different sources, and one of them seemed to give him a smoother wire, less breakage in his drawing operation, and certain other advantages over the other one; and he finally traced that down to the fact that the acid had arsenic in it, or considerably more arsenic than the other one. However, sheet mills had never been able to use arsenic. In fact, the use of arsenic as an inhibitor was patented in this country back in 1908. I think that that patent will ultimately be mentioned. Burgess in 1905, at the University of Wisconsin, investigated the effect of arsenic rather completely. The only thing was that nobody was able to make any use of this knowledge.

Arsenic has a curious property, it prevents steel from pickling clean. If the scale is at all rolled into the surface in a peculiar form, and you have arsenic in the bath, the scale won't come out; so that when you go to de-form your steel for your next operation, it has acid spots, and you get trouble either in the finish obtained, or you get trouble with the equipment with which the steel is processed. So that nobody made any use of arsenic. That has been known for a good many years, but nobody had used it.

When Mr. Gravell found out that arsenic, together with these inhibitors, had such a tremendously powerful restraining effect, and almost stopping effect, he felt that that solved a problem that had been bothering our company for a long time. We were shipping organic liquid, I mean, acid liquids, notably this product I have spoken about, which contained water, and phosphorous acid and alcohol, first, in wooden barrels, and since we had trouble with this liquid, we shipped it in rubber lined barrels of our own design, and our own manufacture. Now, those were expensive barrels.

Alfred Douty

they would only stand up for a few trips, and I have forgotten how much they cost us apiece, but I think it was well over \$8. When Gravelle found out that arsenic in an organic substance as a restrainer, an inhibitor, had this powerful effect, he immediately saw that this was an answer to the problem of shipping acid or other liquids in steel containers, and he tried it out and it worked very well. And we shortly thereafter started the shipping of some acid liquids in steel drums. Now, our inhibiting agents sometimes had arsenic added to them, that is to say, our rodines. But in small quantities, so that by the time they reached the customer we hoped that all the arsenic would be gone.

Mr. Lyon: This is before Gravelle's invention you are speaking of now? A. No, I don't think it is. We had never used arsenic as an inhibitor, because before that time we had known of its disadvantages. But Gravelle, when we—our inhibitors were acid liquids also and contained large quantities of inhibitor, but still we shipped them at first in glass. And by adding a certain amount of arsenic to those materials we felt that they would be safe to ship in steel. In any case, the net result was that shortly after this discovery we shipped many, many thousands of drums, steel drums of quite acid liquids all over the country, without having—without having had any appreciable trouble.

Q: Now, before Gravelle's discovery, which is—upon which this counter-claim patent is based, to your knowledge had corrosive acids ever been shipped in steel containers?

A. No. Not truly corrosive acids. That is to say, concentrated sulphuric acid has been shipped in steel containers, but that is not corrosive to steel appreciably when the concentration exceeds, oh, about ninety per cent.

Q. How about hydrochloric acid? A. I have never heard of hydrochloric acid being shipped in steel, and I don't believe it ever was, before that time.

Q. Before the discovery on which this counter-claim patent is based? A. Yes, sir.

Q. That is, all hydrochloric acid had been shipped in what kind of containers? A. Usually glass carboys.

Alfred Douty

Q. Mr. Douty, you were explaining the counter-claim patent and its relation to the art. I don't believe you finished when we adjourned. So will you continue? A. Well to summarize, what I said before on this subject, I think that the principal contribution of this patent is this: That although arsenic had been known to reduce the attack of acid on steel any reasonable amounts of arsenic were deleterious in pickling processes generally, and therefore arsenic had never come in use as an addition agent in pickling baths.

Secondly, Gravell was the first to discover that organic materials which had restraining power on the action of acids on the metals co-acted with arsenic and certain other metals to give a very much more powerful inhibiting effect. Although the term "inhibiting" had occurred in the prior art, I don't think it had ever occurred to anyone else that inhibiting in the sense of practically completely stopping corrosive action and could be accomplished by the use of these agents. I think, therefore, that the principal point of this patent is this—that nobody had ever conceived it possible so completely to reduce the attack of acid on steel as to make it safe or practical to carry acid solutions in steel containers. Gravell gave definite examples of combinations which would be suitable for that purpose.

Q. Well, I understand from the testimony, Mr. Douty, that for some period of time the plaintiff employed arsenic as the inhibitor, arsenic trioxide, in accordance with the proportion given in the Grebe-Sanford patent here in suit. Will you tell us whether or not such an inhibitor is a material capable of precipitating a substantial protective coating on steel? A. Unquestionably.

Mr. Owen: We admit that is true—that arsenic does have that property.

The Court: With all these patents, unless it be the—well, I will just talk about the two of them; I am talking about this one here (indicating). I have not analyzed the others to see how they are, but our No. 1 patent and this one run crosswise. One covers transportation for one purpose, and the other for another purpose.

Alfred Douty

Mr. Lyon: Of course, our position is that our patent very much antedates theirs, and if there is any conflict, the latest patent is the one to fall. Maybe when Your Honor gets through we will both of us lose them, but I don't think you should hold it against the earlier patent, that there is a conflict with a later one.

The Court: Hasn't somebody got a patent for putting an inhibitor in that would take care of all purposes? Didn't anybody get a patent to that effect? A. Not as far as I know, Your Honor, and I have been over it very carefully.

Mr. Lyon: The fellow who invented inhibitors would probably have objected to all of these patents on the ground that under the law he had all of the benefits of his discovery, and if it was good in tanks, he was entitled to that, and if they were good somewhere else, he was entitled to it.

Mr. Lyon: Mr. Douty, suppose you tell us what your views are as to the comparison of Gravell's invention, with what the plaintiff does when it is transporting the acid down their pipe in the well? A. Well, to follow along the argument that Your Honor has just put forth, it seems to me that if there was a patent with a method of preventing an acid solution from attacking a steel transportation or storage drum, and I think one can say this is a container made out of steel, that is, a pipe line is a container made out of steel, as I conceive it, the plaintiff does not claim it has any function in going down this pipe line whatsoever; the Grebe and Sanford patent, as I understand it, is a method, and is written on a method of getting that to certain formations, that acid, and you cannot treat it until your acid gets into the formation, and the only way you have got of transporting it down there is to put it through the steel pipe. I cannot see that the steel pipe of the plaintiff, or of the defendant, is any different than the storage or transportation container of Gravell. They are both made out of steel, and the problem in both cases is to keep the acid from eating, and Gravell found a pretty good way of doing it.

Q. You referred to Gravell as including containers. I call your attention to the eighth line, the second word in

Alfred Douty

the eighth line on the first page of this Gravell patent, where he says, "Steel drums or containers." Now, is the problem of protecting steel transportation drums, or containers from the corrosive action of hydrochloric acid by inhibitor any different in the case of a tank or drum on a railroad car, or on an automobile truck, than it is in a well pipe, going down a well? A. No, only the one, of protecting the steel drum on a truck is a little more difficult problem. The drum on a truck is supposed to keep the acid in it for hours, days and weeks. The pipe has acid in it for a few hours at most.

Q. Now, just to make one point clear, does it make any difference as to protecting the transportation tank or container whether it be on a truck or on a railroad car, or a pipe down a well, what happens after the acid leaves the pipe or container, what you do with the acid or what you are using the acid for after it leaves the tank or the pipe?

A. As long as the purposes for which you are going to use the acid are not in any way interfered with by the substance you put in it, it doesn't make any difference how you transport it to the spot where you are going to use it, obviously.

Q. There can't be any argument, is there, but what while the acid is going down the well pipe the pipe is a container for the acid? A. No.

Q. Now, I believe you have testified, have you not, as to the circumstances under which this discovery or invention covered by the Gravell counter-claim patent was made by Mr. Gravell? A. Yes.

Q. Were those facts given from your own personal knowledge? A. Yes, such facts as I have given are from my own personal knowledge.

Q. Can you fix the date, or a date prior to the filing of the application for this Gravell patent, on December 11th, 1925, at which time Mr. Gravell was—had made this discovery, of your own knowledge, and can you produce any original record from your company showing and referring to that discovery? A. I have the original record book and I will produce it. (Producing book.)

Alfred Douly

Q. What can you state as to the date this record was made in view of the date appearing on the record, October 29, 1924? A. I know that this material had been reduced to a commercially feasible product and had actually been tested in practice at some time before that date.

Q. Did you see this record on or about October 29, 1924? A. As a matter of fact I believe I got this formula up. Although Mr. Gravell's name appears on it as approving it, I actually got up the formula.

Q. Under his direction? A. Yes.

Q. Now, were there any further formulas for this patent following this date of October, 1924, and up to the date of the application for the counter-claim patent, which was filed on December 11, 1925? A. Yes, there were a number of them.

Q. Have you any more formulas for this same invention of the counter-claim patent in this record prior to December, 1925? A. Yes, I have. I want to point out that that particular embodiment of the invention described at the top of page 2 on the left hand column is by no means the only embodiment. That particular material is, in itself, meant to be transported in steel and then to be useful as an inhibitor to be added to pickling baths or for any other inhibiting purpose.

The Court (interposing): The real purpose of this was to fix it so you could transport it? A. Yes, sir.

Q. As I understand your testimony, these formulas were not entered in this formula sheet until they were completed experimentally and actually placed on sale, is that correct? A. That is correct.

Q. As standard products of your company, or regular products of your company? A. Yes.

Q. Now, have you any further records showing formulas under the counter-claim patent prior to December, 1925? A. I have a formula here which coincides very closely with the formula given at the head of the second column of page 2 of the Gravell patent. This is the material known as Rodine No. 4, our formula No. 103, dated March 14, 1925.

Alfred Douty

Q. Will you compare that with the corresponding formula in the patent? A. This formula is essentially identical with the formula in the patent. I do not see any significant difference. There are more things in our formula book than appear in the formula in the patent, but the end result is exactly what is given by the formula at the top of page 2.

Q. Mr. Douty, did your company ever practice the shipping of any of these products in steel containers? A. Yes.

Q. Can you state when that practice commenced? A. I can't give you an exact date and there is nothing in these formula sheets that tells me the exact date, but I do know that the purpose of putting the arsenic in every one of these formulas was so they could be shipped in steel containers. There wasn't any other purpose in putting the arsenic in. So I am quite sure shipment of these materials in steel containers began certainly somewhere in the neighborhood in the time corresponding to the dates on the formulas, or before.

Q. Well, as a matter of your own independent recollection, can you remember that there were such shipments?

A. Yes, I can. But I can't fix the date any better than by referring to the sheets.

Q. Now, just tell us what your company shipped in steel containers, beginning as near as you can with the dates that you have indicated. A. It certainly shipped the products to which I have already referred in steel containers, with the possible exception of the Scaline, because I don't know of my own knowledge that that was ever shipped in steel; the others I do know were shipped in steel. When the others began, I can't say. In addition to the products I have already mentioned, both arsenic and inhibitors of the type mentioned in the Gravell patent were likewise customarily added to certain of our other products, so that those other products could be shipped in steel containers, to my knowledge.

Q. Then, based on your recollection and based on what

Alfred Douty

assistance you get from this record, about what period, as near as you can fix it, did this shipping in steel containers start? I am not asking for an exact date but a safe date. A. A safe date would be somewhere in the last third of 1924.

Q. And after you once established that practice, to what extent did you continue it? The practice of shipping in steel containers? A. The practice continues to the present day. All acid liquids which are not otherwise deleteriously affected by the presence of materials like arsenic and our inhibitor of the Rodine type, of the early Rodine type, are still so shipped. And that means a great deal of liquid is so shipped.

Q. Can you give the court a picture of how much business you have been doing since 1924 with these materials containing these agents in steel containers, what industries they were shipped to, what the materials were, and some idea who the customers were. A. Well, materials of the type described in the first two formulas which I gave, have been shipped very extensively to the steel industry for use in the pickling of steel over a long period of time. Now, I can't give you a definite idea of how much business that was except that I know that it amounted to an average of possibly some hundreds of drums of that particular compound per year. In addition to that, there have been many more hundreds of drums of our body cleaner Dioxidine shipped in steel by the aid of additions of arsenic and other organic material of an inhibiting nature.

Q. What were you shipping that Dioxidine in to the automobile or paint industry prior to Mr. Gravell's invention set forth in the counts in patent? A. At first in glass, then in wooden barrels, and then when those wooden barrels leaked too badly Mr. Gravell developed a new type of rubber lined barrel, on which he had a patent.

Q. To what extent did this counter-claim invention of shipping in the steel containers replace those other forms of containers? A. It replaced them altogether. I must modify that statement—to the extent that we still supply

Alfred Douty

the Oxidine to such retail customers as can only buy a gallon, in gallon bottles, but other than that we ship quantities from 10 gallons upward in steel.

Q. Did you give, or can you give any estimate of the value of the products that have been shipped under this counter-claim patent by your company in steel containers, just as a round figure? A. Well, it would be pretty much of a guess.

Q. Well, make a conservative estimate. A. Well, it would be something over two million dollars, and something under ten million dollars worth, but I cannot tell you exactly.

Mr. Owen: You mean that you shipped in steel containers? A. Yes, products of that value.

Q. Can you give us the names of a few of the representative customers that such shipments have been made to? A. Oh, yes. Hudson Motor Car Company, Packard Motor Car Company. Shipments were made to the Studebaker Company, the Ford Motor Company, Chrysler Motor Company. United States Steel Corporation, to its various plants all over the country, including the Carnegie-Illinois Steel Company, and various other branches. I would say practically to every, pretty near every representative motor or steel company—I would say that they have at some time or another received products shipped in steel, the steel containing materials in accordance with this patent.

Q. You have covered the steel industry and the automobile industry. What about the oil industry? A. Well, in the oil industry, among other people, we have shipped to the Dow Chemical Company.

Q. About when, do you have any dates? A. I don't remember exactly when, but I have seen the invoices, so I know we shipped to them.

Q. Have you any idea when it was? A. Well, I think it was probably around 1934 or 1935.

Q. Any oil company? A. We have shipped—we did some business in the south, in the southwest, through Tulsa agents, whose names have escaped me for the moment, we

Alfred Douty

sold quite a little rodine down there, as far as I know to oil companies, but I cannot be sure of that. I have seen invoices where we shipped some Rodine No. 2 to the Gypsy Oil Company.

Mr. Owen: I would like, Mr. Lyon, at this point, if you would please have the witness identify a little more definitely these materials which were shipped to these different industries.

Mr. Lyon: Well, I will be glad to do that.

Q. If you can elaborate on that, Mr. Douty, or fill in that testimony that Mr. Owen asks for, if you can give him what he wants? A. Well, the automobile industry got mostly body cleaners, containing phosphoric acid, alcohols, rodine and arsenic.

Mr. Owen: What were those body cleaners called? A. Deoxidine. They also got some Deoxiline.

Mr. Owen: Have you got the formula for those? A. Why, yes, but I am not so sure that I care to give it to you, because some of them are still in use.

Mr. Owen: They contain phosphoric acid? A. Yes.

Mr. Owen: And no other acid? A. No other acid.

Mr. Owen: What did you ship to the Dow Company? A. I am not sure that I know right now; either Rodine or Murodine, I can't remember which.

Q. What was Murodine? A. Murodine was a material, an inhibitor made under certain other patents not in suit here. It did not contain any arsenic.

Mr. Lyon: Did the—do you believe it corresponded to the claims of this counter-claim patent here in suit? A. I am inclined to believe that—

Q. (Interposing): It would depend how it was used, I suppose.

Mr. Owen: It would depend on what it contained. A. Well, in any case, it wouldn't correspond to the claims of the patent, because, as I recall, we didn't ship Murodine in steel at all.

Q. Do you remember whether you ever shipped any Rodine in steel to the Dow Company? A. I can't re-

Alfred Douty

member. If we ever did, it would appear in the deposition of Mr. Spruance.

Mr. Lyon: We will turn to a new subject now, Your Honor. I want to have the witness present patents which will be relied upon by the defendant as constituting the pertinent prior art ahead of the Grebe-Sanford patent in suit. I will try to do that as fast as I can. Of course, we are permitted to rely on such of those as the plaintiff has already offered in evidence, and I don't think it would be necessary for me to go over those again. But we have some others, and I would like to mark this group of patents as DX-294, and I will identify the patents at this time.

(Whereupon the group of patents referred to was marked DX-294.)

Mr. Lyon: Now, Mr. Douty, can you go through these various patents and identify which ones you are talking about and tell us in so far as they are pertinent here what they disclose and see if you can classify them in some way that will help the court. I have in mind if they only show inhibitors for corrosive acids, say that that is the classification they belong in. If they show adding inhibitors to acid for removing limestone scale, or some such particular purpose analogous to the Grebe and Sanford patent, that you call attention that they fall in that class. I think that will help the court the most, because I do not think there is anything very difficult about these patents, Your Honor. It is just a question of getting them classified and getting them in your mind. A. I had thought that logically the prior art patents really belong into three classes: those which indicate the general principles of inhibiting, what inhibitors have been used for, and how generally they have been applied; those which showed particular inhibitors mentioned in the patent in suit, the Grebe and Sanford patent in suit. Before I read any of these, or refer to any of the patents, I just want to go briefly over the list of inhibitors to which Grebe and Sanford specifically refer. Grebe and Sanford specifically refer, toward the bottom of column 1 of page 1, to arsenic acid, to arsenic trioxide, or a

soluble arsenate or arsenite. Toward the bottom of column 2 of page 1, Your Honor, they begin to tell what inhibitors they have in mind. And in addition to those arsenic compounds Grebe and Sanford refer to other inhibitors such as cyanides, organic nitrogen bases such as aniline, phenylhydrazine, pyridine, quinoline, acridine and derivatives thereof, organic sulphur compounds such as mercaptans, as well as various by-products of industrial processes, such as sludge acid from oil refining and residues from acid sulphite paper manufacture.

Referring now to the Lavery patent No. 856,644. That is the first one in the book after the Fraseh patent, Your Honor.

The Court: Maybe someone will tell me, now that I am starting with this, was this both in the file wrapper and before the Tenth Circuit?

Mr. Lyon: Yes. This one was cited by the Patent Office and was before the Tenth Circuit. Lavery is obviously a practical man rather than a chemist, since he refers to the use of a pickling bath containing a hydrocarbon. Hydrocarbons are not soluble in a pickling bath, and don't do much good in a pickling bath; but on reading his specification one finds that the agent that he is interested in is tar sludge, it being a waste product of the oil refining process containing tar and oil and sulphuric acid. That appears at about line 35 of the first page. Now, it likewise appears from the line following that, (reading): "I preferably add the sludge to the acid generally about one part sludge to 15 parts acid by weight. This will give an excess of oil to the acid, the surplus oil being afterwards skimmed from the top of the bath."

Actually, that oil tar sludge contains a great many different organic chemical substances, and you will find, Your Honor, as we go along that many of the inhibiting agents proposed by other individuals are such industrial wastes as this tar sludge. If one consults the classical work on petroleum, *Das Erdoel*, which means petroleum, by Engler, one will find that oil contains, among other things,

Alfred Douty

nitrogen ring bases, and later on patents will be referred to which mention nitrogen ring bases as actually preferred agents to be used in pickling baths.

It will be found that there is a reference to tar sludge, I think, in the patent in suit.

The Court: Here is the reference in the patent in suit, (Reading): "Such as sludge acid from oil refining and residues from acid sulphite paper manufacture, etc." A. That is right, Your Honor. Well, now, with such agents, there is no guaranty that one of them will be as strong as another, or will contain the same ingredients as another, since they are industrial waste products.

The Court: But what you do say is that both patents refer to that ingredient or those ingredients? A. That is right.

The Court: Is there any difference between the two? They use different words there. What is your interpretation? A. I do not see how you can find any difference. He says that tar sludge is the material I preferably use. That is Laverty. On account of its cheapness, it being a waste product of oil refining process. I think that is the same product to which Grebe and Sanford refer. They refer to it as various by-products of industrial processes, such as sludge acid from oil refining. Now, obviously, a waste product of oil refining, being a tar sludge, is the same thing.

Mr. Owen: In the Gravell patent where it refers to nitrogen ring compounds, would that be the same thing as Laverty referred to? A. Not all nitrogen ring compounds, although ring compounds may be contained in the tar sludge. Line 50 of page 1, Gravell patent, he refers to—

Mr. Owen (interposing): That is the same thing Laverty refers to? A. Yes, all these inventors have been in the habit of reciting materials from the previous patent literature as examples of the things they mean. Grebe and Sanford and Gravell were no exception to the general rule. The object of that Laverty invention was to provide a pickling bath, among other things, in the use of which a scale or oxide is removed from the metal without appre-

Alfred Douty

ciably attacking the surface of the metal. He repeats that phraseology almost exactly in the second column of page 1, where he says: "the surface of the metal is not attacked by the acid in the bath to any appreciable extent during the time required to remove the scale from the metal." Actually, of course, crude materials of this kind are unable to afford awfully good protection unless they are used in very large quantities.

Mr. Lyon: But to be compared in what way to the object of Grebe and Sanford? A. The object as expressed there is identical with the object of Grebe and Sanford.

Q. You will have to tell us what it is. A. Namely, to remove something. We all know it isn't exactly the same as Grebe and Sanford in that in this case Laverty is interested in removing scale, as I talked about this morning, from the metal without appreciably attacking the surface of the metal. Grebe and Sanford are concerned with getting the acid down into the well without appreciably attacking the metal. The problem is similar but not identical.

Well then, the next patent is the one to Beneker, No. 914,916.

Mr. Babcock: Your Honor, that patent wasn't cited by the Patent Office but it was considered in the Williams Bros. case.

Mr. Owen: I have a note it was cited in the Grebe file wrapper.

Mr. Babcock: I may be mistaken.

A. The only thing I failed to say about the Laverty patent was he says "Other than sulfuric acid may be used and materials other than oils containing hydrocarbon"—in other words, he means any acid. Beneker disclosed the use of arsenic acid in a wire and metal cleaning bath. I mention it particularly because arsenic is a preferred agent of the Grebe and Sanford patent in suit, and also because Beneker gives a description here which might be helpful to Your Honor, of pickling in which he says before all the scale has been loosened the exposed metal has been vigor-

Alfred Douty

ously attacked by the acid. Beneker patent about line 20 of page 1. That is a description of the ill-effect that he is trying to avoid. He mentions around line 13 that the pickling bath may consist of sulphuric or hydrochloric acid. He mentions the use of arsenic in quantities as low as 5/1000% of arsenious oxide and he seems to prefer to use from .001 to .005% of arsenious oxide, line 65, page 1, where he says: "preferably from .001% to .005% of a compound of arsenic, as, for instance, arsenious oxide." I call Your Honor's attention to the fact those are very much smaller quantities of arsenic than are referred to in the patent in suit which refers to quantities in the neighborhood of from 1 to 5%. The reason for that is very large amounts of arsenic completely spoil the pickling operation. They coat the metal with an undesirable coating. They prevent the removal of scale from the irregularities of the surface and otherwise affect the desirable operation. That is a problem which does not exist when the acid may act upon a surface which does not necessarily have to be clean and beautiful after the operation, as in the Gravell or the Grebe-Sanford processes.

Q. Let's go to the next patent. A. All right, the Holmes patent No. 1470225. This patent is on the application of aldehydes as inhibitors. Aldehydes are not mentioned in the Grebe-Sanford patent, although I think they are mentioned in the Gravell patent. The principal matter of interest in the Holmes patent is that this is one of the early examples of the use of inhibitors for another purpose than merely pickling heat scale off of steel. At line 10 of page 1 Holmes states: "This invention is particularly applicable for the pickling of iron or steel wire or sheets in mill practice, but is also useful in many other ways, such as for cleaning or freeing iron or steel in any form from rust or oxides, or for removing scale such as boiler scale or the like from sheets or tubes."

Now, the meaning of that boiler scale is a deposit that is left by the evaporation of water in the boiler, and it consists usually of calcium and magnesium salts, and often is

Alfred Dcuty

not very far in composition from the composition of rock found in oil wells, or of common limestone. Therefore, the problem of freeing the boiler from boiler scale, or the boiler tubes of the boiler from boiler scale is very analogous to the problem of the patent in suit. You want to dissolve some type of limestone-like formation by means of acid which has to be transported in steel. In this case, one wants to remove the undesirable encrustation from the steel boiler without harming the boiler, and it is that particular analogous application for which I think this patent is most interesting.

Q. In either case, you want the acid to act on the lime material and yet the acid contains some inhibitor so that the acid will not eat or dissolve the iron? A. That is correct. And Holmes states that examples of suitable acids are sulphuric, hydrochloric, phosphoric and even acetic, although these weaker acids would probably not prove effective, that is, acetic and so forth. I was reading from line 60, page 1.

Q. All right. Let's go to the next patent. A. Next is the Gravell patent to which reference has just been had, and I don't think we need to go any further than that.

The Court: That is the defendant's patent in suit?

A. Yes, sir.

Mr. Babcock: This patent was considered in the Patent Office and also by the Tenth Circuit.

A. The next is the Fischer and Stegemeyer patent, 1,736,282.

Mr. Babcock: That was considered both in the Patent Office and the Tenth Circuit? A. The interest of this patent is merely in disclosing still another class of inhibiting agents, namely, the reagents resulting from sulfonating mineral oil. As a matter of fact, the agents to which this patent refers are agents which are produced in the refining of very highly refined white oil, medicinal oil, and they are described by the patentees on page 1, at lines 61 and 62, as (Reading): "The sulfonic reagents resulting from this refining treatment are of very high molecular weight,

Alfred Douty

usually between 200 and 500, and are classified for convenience by their various characteristics of chemical behavior, such as their solubilities, etc. * * *

"Generally speaking, the bodies fall into two classes, those which are oil-soluble in the presence of water, and those which are oil-insoluble in the presence of water."

And Fischer and Stegemeyer want to use the water-soluble members of this class as inhibitors in the pickling in an ordinary pickling operation.

Q. Now, does anything of the Grebe and Sanford patent correspond to those sulphonic reagents of Fischer and Stegemeyer? A. It is very probable that the sludge acid from oil refining of Grebe and Sanford, as well as the sludge acid of Laverty, contains some of the same compounds that are disclosed here by Fischer and Stegemeyer.

Q. Just exactly what sludge acid you would have would depend upon what you were treating with your sulphuric acid, wouldn't it, what oil, you were treating? A. It would.

Q. These fellows were treating a particular mineral oil? A. Yes.

Q. A medicinal oil, and the patent in suit of Grebe and Sanford does not say what they were treating; they just included all sludge acids, isn't that right? A. Yes.

Q. All right. Let us turn to the next patent. A. The next is the Rhodes patent, to which I have previously referred, No. 1,746,677.

Mr. Babcock: This Rhodes patent was not considered by the Patent Office, but was cited in the answer in the Williams Brothers case.

A. The Rhodes patent is of importance for two reasons. The class of inhibitors which Rhodes discloses are acridines, the formulas of a number of which appear in the first column of the second page of the patent. Acridine and derivatives thereof are mentioned at the top of the first column of the second page of the Grebe and Sanford patent. The second reason, and more important reason, for including Rhodes, is that Rhodes has given a fairly good exposi-

Alfred Douty

tion of the use and purpose of inhibitors. I should like to read first from the beginning of the Rhodes patent. (Reading): "The invention relates to inhibitors or restrainers useful in chemical and electrochemical processes for preventing or retarding the evolution of hydrogen at the surfaces of metals immersed in the solution or for otherwise preventing or retarding the chemical action of acids on metals."

That points out an interesting fact, that steel and the ordinary acid corrodable metals always corrode with the evolution of hydrogen in strong acid solutions, and anything which will prevent or retard the evolution of hydrogen at the surfaces will serve to prevent or retard corrosion. I wish to also call attention now to line 43 of the first column on page 1, where Rhodes says, after having described the use of his inhibiting agent in pickling, and so forth, (reading): "Another use of the process is in the removing of the metal oxide or carbonate forming on copper or other non-ferrous materials. Another advantageous use is in eliminating the scale forming in pipes and in the tubes of automobile radiators which often seriously interferes with the proper flow and circulation of the fluid through the radiator."

Now, that is another use which I consider highly analogous to the process of the patent in suit, namely, that you are to dissolve calcareous deposits formed by deposition from water on metal surfaces. In column 2, of page 1, at line 65, the patent reads (reading): "In its broader aspects, my invention contemplates the use of the inhibiting agents hereinafter more fully described in connection with any chemical or electro-chemical solution or reagent which under normal conditions of operation will evolve hydrogen at the surface of a metal immersed therein. In other words, my invention provides a means for causing desired chemical or electro-chemical reactions to take place and without substantially decreasing the rate of said reactions causing an inhibiting action retarding or actually preventing the evolution of hydrogen which would normally

Alfred Douty

take place without the presence of the inhibiting agents."

I think that might be written a little more clearly to say that he wishes to stop all processes which cause the evolution of hydrogen from an acid solution without stopping those processes which do not evolve hydrogen from solution.

The Court: Is there a definition in chemistry of agent and also reagent, so I can have that? A. Well, an agent isn't strictly speaking a chemical term at all. An agent is just a general term which means any person or thing which performs a function which is desired. A reagent is a substance which enters into a reaction, obviously with some other substance or substances.

The Court: Substance or what? A. Enters into a chemical reaction. Anything which enters chemical action with anything else is a reagent.

The Court: Hydrochloric acid and this limestone? A. They are both reagents. Hydrochloric acid and steel both the steel and acid are reagents.

Q. (By Mr. Lyon): You have said this Rhodes patent specifies the use of acridines. Compare that with the third reagent or agent specified at the first line on page 2 of the Grebe-Sanford patent. A. " * * * acridine and derivatives thereof," which appears in the first and second lines of page 2 of the patent in suit, Grebe and Sanford patent, describes the materials that Rhodes here refers to.

Q. So both Rhodes and Grebe and Sanford, so far as acridines are concerned, call for the same inhibitors? A. Yes, sir. The next Rhodes patent, No. 1,746,676, I will not refer to in any detail. It recites certain other acridine derivatives.

Q. Otherwise the disclosure has the same effect as the preceding Rhodes patent? A. It has. In fact, it is almost verbatim the same as the other one except for the actual agents therein disclosed.

The next patent to Vignos, No. 1,750,651.

Mr. Babcock: It was cited in the Patent Office but it wasn't considered by the Tenth Circuit.

Alfred Douty

A. - The Vignos patent is cited for two reasons; in the first place, the preferred agents of Vignos are sulphonated mercaptans. Now, mercaptans, without reference to sulphonation, are referred to in the Grebe and Sanford patent on line 3 of page 2, such as mercaptans, it says: "organic sulphur compounds, such as mercaptans." These compounds of Vignos are still mercaptans. They are sulphonated mercaptans, he says, and for that reason I mention them. Vignos also recognizes the usefulness of his inhibitors, in quoting from line 21 of the first page: "The removal of deposits collecting within a water or steam circulating or distributing system, and also for removing scale such as boiler scale and the like from sheets and tubes." And Vignos also recognizes that these inhibitors may be added to the acid transported in an acid tank car to prevent corrosion of the car by the acid and can likewise be used to diminish excessive corrosion by water in systems employing mine waters, which is getting pretty close to what you are trying to do in the patent in suit.

Q. I think if you just tell the court what inhibitors these patents called for, as you come to them, and for what purpose, that would be all that you would have to testify to about them, because they can always be read, and I think those are the pertinent things that the court is interested in. A. The Harrison patent, 1,766,902, relates to an inhibitor from the 1-2 Dianimo ethane. It mentions a number of derivatives, and it is used for pickling operations, and it says on line 7 that it is also useful for cleansing tubes from scale by pickling and for removing the scale and corrosion products that accumulate in water pipes, and it may be used in any case where iron or steel is to be freed from rust or oxides, or wherever it is necessary to treat iron or steel with acids and solution of the metal is undesirable. It says that it is useful in any case in which it is necessary or desirable to use acidic materials in contact with iron or steel.

The next patent is Corson and Lawrence, 1,773,953, and refers to a certain special type of sulphonation prod-

Alfred Douty

ucts of mineral oils, which contain in the neighborhood of 10 per cent or more total sulphur as inhibitors. They are ichthyol-like materials. They are in the class of organic sulphur compounds, but not very closely related to any of the other materials mentioned in the patent in suit. It is also stated that they are useful in removing undesirable encrustations and corrosion products associated with metals which are submitted to acid treatments, and it says on line 69: "There are, however, many other processes in which acids could be used to dissolve rust or encrustations upon the metals." It mentions the use of the materials in hydrochloric acid.

The next patent to Lawrence, 1,780,594, refers to the type of inhibitors known as the thioglycollic acids. Its derivatives contain the radical $\text{COOH-CH}_2\text{-S}$. And once more it refers to the general use of inhibitors to remove either oxides, rusts, scales, salts or other undesirable encrustations and corrosion products.

The Court: One would think many of these are almost identical. I suppose, if you come to read them, there is some theory on which they claim an improvement on the previous one.

Mr. Lyon: We are really putting them in here, Your Honor, just to show that these various agents, that all the inhibitors that are mentioned in the Grebe-Sanford patent and many others are all known to be inhibitors, and then to show that as to certain of these patents that they were known generally for uses wherever the acid contacted the metal, and, specifically, many of them describe where the acid is acting on a lime material. They don't really add very much to the Gravell patent that our counter-claim is on. I think that is really the most pertinent prior art patent for Your Honor to consider.

The Witness: This is another one of a large class of organic sulphur compounds.

The next patent to Lawrence adds no new ideas to the ones that we have just described and disclosed. And it claims to use as inhibitors compounds which are known as mustard oils, the isothiocyanates.

Alfred Douty

The next patent to Calcott, 1,785,513, is of interest because it mentions specifically the use of mercaptans, which are of the class of agents described in the patent in suit, and which have been mentioned here as having possibly been used by the plaintiff. The patent specifies generally the treatment of metals with acids, and this is on line 10—"For the purpose of inhibiting this solvent action on the free metal, certain types of substances have been added." And it goes on to say that these mercaptans are particularly effective.

The patent to Burke, No. 1,789,805, patents the use of alpha amino acid, and particularly substances derived by hydrolizing animal proteins which include the particular albumenoid protein, keratin. It is interesting only because it is another, still another of the large class of inhibitors which, however, can be related to a much earlier inhibitor that is mentioned in the art, namely, gelatin, since gelatin is one of the proteins which is hydrolized in hydrochloric acid to give you certain amino acid. In the second column of page 1, at line 64, a paragraph begins which speaks of the transportation or storage of acid solutions in metal containers. This patent, of course, was filed in 1929; it was some years after the Gravell patent had issued.

Nextly, the patent to Corson, No. 1,809,621, mentions a type of chemical inhibitor not heretofore mentioned, namely, the thiuram compounds, notably the thiuram sulphides, and it makes quite a point of the removal of scale or other acid soluble deposits from metallic articles.

Now, I think that closes all of the patents which refer specifically to inhibitors.

Mr. Lyon: We have a stipulation which I would like to read in evidence in this case, which is page 61 of the deposition of Mr. Boundy, taken in Midland, Michigan, on July 25, 1940, which reads as follows:

"It is hereby stipulated by and between the parties to this litigation that in all the work done by the Dow Chemical Company, or anyone in its employ, or on its behalf, prior to February, 1932, no inhibitor of any kind, nature

Alfred Douty

or description was used in connection with the acid used in the treatment of brine wells, and the reports and records of the Dow Chemical Company so show.

"Mr. Owen: The proposed stipulation is accepted."

Mr. Lyon: Now, Mr. Douty, you have called attention to these prior patents. I would like to have you tell us as a matter of your own knowledge, and to what extent inhibitors were being used with hydrochloric acid prior to more than two years before the application for the Grebe and Sanford patent in suit, what use was being made of them commercially, and for what purposes, and to what extent, to your knowledge? A. Prior to approximately 1930, in other words, some time in 1930—well, I know that at that time we were selling inhibitor to some people who pickled with hydrochloric acid. We were selling inhibitor to others who were removing various types of calcareous deposits from equipment of one kind or another, with hydrochloric acid. I am not going to be able to tell you to what extent, because I do not know relative to our whole business how much of it went into these particular uses that I am describing, but I know that it was used—

Q. (Interposing): You know that you were selling those materials for commercial use? A. Yes. Now, I also know that on at least one occasion, and I do not know how many more, the acid was sold to be used for some purposes in connection with an oil well, down an oil well.

Q. Who was that sold to? A. Well, I have seen the records of the Gypsy Oil Company sales where they used acid, as I have been told later, for cleaning out—or freeing tools or removing gyp from the pipe. Prior to 1930, or September, 1930, I can't think of any other uses in connection with hydrochloric acid at the moment, and I don't know the extent of the use in any case.

Q. Were others selling inhibitors? A. Yes.

Q. Your own company was selling inhibitors, was it not? A. It was.

Q. Beginning when, as far as your knowledge is concerned? A. As early as December, 1923, and continuously thereafter.

Alfred Douty

Q. And did you have competitors in that business?

A. Yes; we have had a number of competitors. The Grasselli Chemical Company sold inhibitors. I don't know exactly when they began to sell. But I know they have been doing it for a number of years.

Q. Well, they were doing it before 1930? A. I am sure they were. How much earlier, I don't know. The Barrett Company were selling inhibitors pretty far back. Then—let me see, I don't remember just when William M. Parkin began to sell. William M. Parkin of Pittsburgh. And a fellow named Addison Hoffman of Pittsburgh. And I think Parkin used to sell things for him. We have had altogether some thirty or forty competitors. Some of them are still in existence. Most of them aren't.

Q. Then you can state that this knowledge of the use of inhibitors was not confined to the patent art, but was actually commercially practiced prior to 1930? A. Oh, yes.

Q. On a wide scale, for various purposes, to protect the metals from the corrosive action of the acid? A. Oh, I am sure of that. I know that in February of 1930—on January the 3rd—let's see, it says here—I think that must be a mistake. It says Friday, January 3rd, 1929, I was supposed to have delivered a paper on the use of inhibitors in the pickling of steel before the Philadelphia Branch of the American Electroplaters Society. Now, whether that was 1929 or 1930, I can't say now, because this is the February, 1930, issue of the Quaker City Platers Reminder from which I am reading. Immediately under the title of my article it says "Friday, January 3rd, 1929." I can't say which year that was. But, in any case, at that time I read a paper on inhibitors in which I told something of the art, and apparently it was not particularly mystifying to the platers who were at that meeting.

Q. Was that paper printed and published? A. Yes. This is a copy of it.

Mr. Lyon: I will ask that that be marked DX-295.
(The copy was thereupon marked DX-295.)

Q. (By Mr. Lyon): You have referred to the sales

Alfred Douty

to the Gypsy Oil Company. We already have in evidence these exhibits at page 459, 461 and 463 in the appellate record in the Williams Brothers case. Are those photostatic copies of the records you had in mind? A. They are.

Mr. Lyon: These are the orders from the Gypsy Oil Company, Your Honor, to Mr. Douty's company. For the Rodine No. 2 which Dr. Wescott recommended be used in the treatment down in Oklahoma. I think those are already in evidence. If they are not, I will declare them so now, with Your Honor's permission.

The Court: All right.

Mr. Lyon: Mr. Douty, in preparing that article or address of yours which we have just referred to a few moments ago you made quite a study of the history of inhibitors, did you not, and where they were first known and the extent to which they were known in past history? A. I read what literature was available on the subject.

Q. Now, there has been some suggestion here about what was known about inhibitors at the time of Frasch. The work Frasch was doing, Frasch applied for a patent on June 27th, 1895. Tell us what was known about inhibitors at that time, what was known—or might have been known in scientific literature and whether they were in use or commercially known at that time? A. In that paper that has just been marked as an exhibit, Your Honor, you will find that the earliest reference to the commercial use of inhibitors, as they are called today, that I was able to find, was in the early twentieth century, starting somewhere around 1907 or 1908. To be sure, I found as early as 1845 a paper by a Frenchman by the name of Millon in the Comptes Rendus, on a memoir upon the action of water on metals in the presence of acid and salts. That, indeed, did mention that certain metals had either accelerating or retarding effects upon the rate of solution of metals, different metals, in acid. But, it was a purely scientific observation which, as far as I know, no technical use had been made until 1896; I think I rechecked that date, and that was the date when this fellow Meurice published in the

Alfred Douty

proceedings of the Belgian Chemical Society an article in which he described the effects that he had obtained with arsenic in the pickling of wire in his mills. Now, that is the earliest article that I was able to find which mentioned any practical use of any inhibitor. That use was in a Belgian wire mill, as far as I was able to find out.

Q. Well, as far as your search revealed, could you find any reference to the commercial use of inhibitors or knowledge of inhibitors in the United States back at the time of Frasch's work in June, 1895? A. No, none at all.

Q. And do you believe your search was a thorough search? A. I think it was a fairly complete search. I think it was in 1901, or somewhere along there, that an investigation of the effect of arsenic was made by Burgess, but I may be mistaken in that date. It was certainly in the 1900's, and even then there was no commercial use of it so far as I know. Beneker's patent came out in 1909, in March, 1909. It was applied for not over a year or so earlier, and to be sure I had heard from old picklers by word of mouth rumors of the addition of certain things like mouldy flour and things of that kind to produce a foam on a pickle bath further back, but they could not be sure of the date, and when I asked them it was in the 1920's, and how far back that experience really went it was impossible to say. I could find nothing written on the subject earlier than the twentieth century.

Q. You couldn't find any record of the sale of inhibitors in this country or the existence on the market of inhibitors prior to what date? A. Well, as a matter of fact, I don't think that there was a commercial inhibitor sold in this country before 1920.

Q. And who made the first sale, as far as your knowledge goes? A. I am not sure but what the material was known as Picklette, and it was a solution of coal tar bases extracted from anthracine oil, and I wouldn't be surprised if it had been put on sale by the American agents of an English firm.

Q. About 1920? A. Yes.

Alfred Douty

Mr. Lyon: While we are about it, I don't think this Williams Bros. record has been given a number. Only parts of it are in evidence; the record shows which part, but under the practice it should be offered. I will ask that it be stamped DX-297.

(Whereupon Exhibit DX-297 was marked by the reporter.)

Mr. Lyon: Before I ask you to give your conclusions from the corrosion curves that Mr. Hathorn has produced, will you please tell the court what experience you have had in making corrosion tests and interpreting and understanding the results of corrosion tests, how long have you been doing it and to what extent, and to what extent you are familiar with the procedure and interpreting the results?

A. Starting in 1923, in the late summer, I began to make corrosion tests, particularly tests on the corrosion of metals, particularly steel, with acids, very extensively. And I continued making hundreds and thousands of such tests by various techniques, some of which I developed myself, up to and including the present day. For up to the period up to about 1930, I would say there was scarcely a working day where I did not make half a dozen such tests by one means or another, one method or another. Some of the earliest work I did on corrosion by acid had for its object the determination of conditions under which metal surfaces could be made—brought into such a condition as to make corrosion tests more or less uniform and reproducible.

I think I will state the conclusion first, that I never found such conditions. I have tried every conceivable method of cleaning and pre-treating and it almost works down to the fact that you have got to get—to reduce the thing down to a statistical average before you can believe very much of any corrosion series. Among other things that I thought might be very uniform for the purpose of testing for corrosion was piano wire. I thought music wire from one roll of very fine music wire would be about as uniform a specimen as I could possibly get. Well, I found that any results you got from such a piece of music wire,

Alfred Douty

within any reasonable period of time, failed to check each other by fifty per cent or more, repeatedly. And it has been my experience throughout that only by the very greatest precautions as to reproducibility can you get results that are at all close together, particularly when you are trying to measure interference with normal corrosion rates by the presence of accidental or intentional impurities. I won't go into it any further, except to say that it is a subject with which I am quite familiar.

Q. In connection with your work in preparation for this case, I understand you were able actually to devote only a limited amount of time to your preparation, is that correct? A. Very little time.

Q. You didn't have time to stop your other work and run a six months' or a year's series of tests to prepare for this case, is that right? A. Nothing like that.

Q. Well, did you have time to make any laboratory tests? A. Yes, I made some laboratory tests whose object was to find out whether the Menaul process under the best conditions could actually be operative. I recorded those tests and the results thereof in a laboratory notebook which I produce. (Producing book.) As a matter of fact, this particular book has a variety of things in it. It is just a loose-leaf notebook, but every single bit of data that I have I will now produce (handing sheets to Mr. Lyon). That is all. The rest of the notebook is filled with notes taken at this trial.

Mr. Lyon: These sheets seem to be numbered or lettered "A" to "W," consecutively, and then there are six more sheets. That will give anybody wanting to count them information as to whether they are all here or not. I will ask that these be received and marked DX-299.

(The sheets referred to were marked DX-299.)

Q. (By Mr. Lyon): These notes, or these writings, constituting DX-299, are all in your own handwriting, are they? A. Yes, sir. They contain my conclusions, any conclusions that I reached as a result of those tests. I ran four series of tests here—

Alfred Douty

Q. (Interposing): Will you just explain to the court what the tests were and what conclusions you drew from them? Of course, the exhibit itself is in evidence, but just give the court a summary, if you will, please. A. The first three tests were intended to evaluate the effect of the contact of a piece of steel with lead in protecting it from attack by 15 per cent hydrochloric acid, and they were made under various conditions of contact and time, so that I was trying to isolate, if any, the effect that the dissolved lead chloride might have, and the effect that the electrical connection might have, and the fourth test, which repeated the first one, was made much later. These tests were performed in December of 1939, and then I did no further work except for several days in June of 1941 when I did the fourth test. That was the first time I ever heard about copper having anything to do with this case, so I made some tests involving the use of copper in proportions somewhat larger than had ever been found in any of the defendant's acids as reported to me. So that I have four tests here of a Menaul system, really, and variations of the Menaul system, in order to find out. Then I find in this notebook also a few measurements of the potential of lead versus steel in hydrochloric and sulphuric acids, which have not been transmitted to anybody else, but which I simply found in these notes.

Q. But they were made by you? A. All made by me. All this work was by me, helped by nobody. All on a laboratory scale.

Q. Now, will you just give us what your findings and conclusions were as they are expressed in the exhibit? A. At the conclusion of my first test I had reached the following conclusions:

1. Lead chloride is a slight inhibitor of the corrosion of steel by hydrochloric acid of the strength used by oil well treaters.

2. Connecting the steel to a piece of lead protects the steel far more perfectly than does adding lead chloride to the acid.

Alfred Douty

3. In acid containing lead chloride the protection afforded the steel by connecting it to a piece of lead is not only not improved but is actually impaired by the presence of the lead chloride.

The Court: I think I understand that, but the two conclusions seem inconsistent. A. They would, Your Honor.

The Court: In other words, at first I had the idea the lead connected to the iron was better than the lead flowing loose in the hydrochloric acid? A. That is right.

The Court: Then I get down to the second one and it is just the reverse of that, isn't it? A. I think Your Honor will understand the conclusions better when I describe the experiments. They are very simple and I think conclusive.

The Court: All right.

(Witness continuing): The fourth conclusion is—lead chloride dissolved in the acid does not produce a continuous, adherent film of lead on the steel.

5. Steel connected to metallic lead acquired in the acid an adherent, apparently continuous film of lead. Incidentally, I base that not upon any analysis of lead but based upon an actual difference in weight, which is considerable. In other words, a piece of steel was weighed at the beginning of an experiment and at the end of the experiment. In addition to that, the solution is analyzed for iron at the beginning and end of the experiment. Now, the loss in weight of the steel should be the same as the increase in iron in the solution. But it turns out that when the steel is connected to lead, the loss in weight of the piece of steel is considerably less than the amount of iron found in the solution. Now, that means that the steel must have lost some weight of iron and gained some weight of something else. Otherwise, it would have lost as much weight as the iron I found in the solution.

The Court: Iron has to get away somewhere. A. It did go away and yet the steel didn't lose that much weight. So I was able to weigh that difference in a number of experiments and conclude the steel had from 3 to 5 millionths of an inch of lead on it at the end of the experiments.

Alfred Douty

Mr. Lyon: You were reviewing your laboratory work, Exhibit No. 299, and I asked you to make a summary of the work and read the conclusions as you arrived at them and recorded them in this exhibit, and I think you had just finished reading the conclusions on your first three experiments, which were, as I understand it, experiments you did to determine the effect of bonding steel to lead. A. Mr. Lyon's question was not exactly correct. I had only read the conclusions which occurred at the end of the first experiment that I had run. I then ran a second experiment, and at the end of the second experiment I had not arrived at any further conclusions in quite the same form. I ran still a third experiment, and after I had finished the three experiments I had confirmed some more ideas that I had had. I think before discussing the conclusions, I had better state briefly what tests I made and what they were. They were entirely laboratory experiments. The object was to find out the rate of solution of iron from ordinary tank steel in plain acid, where the steel panels alone were in the acid. In plain acid, where the steel panels were resting in contact with lead strips, and in plain acid where the steel panels were in the same beaker with, but not in contact with the lead, and then a second series of three in which the acid was initially saturated with lead chloride. That is, I had put in as much lead chloride as the acid would take up, and then the steel panels, certain steel panels were placed in a beaker full of that acid alone and another beaker containing a lead strip and in contact with a lead strip, and in a third beaker—in the same beaker, with a lead strip but not in contact with it. The way that was done, I cut three inch squares of tank steel of 14-gauge, which is about 78 thousandths of an inch thick, and lead strips about $1\frac{1}{2}$ inches by 10 inches by $\frac{1}{8}$ th inch were bent into a "U" shape about three inches across the top of the "U" and the arms about three and a half inches long.

In those experiments where the steel was in the beakers alone, I chose beakers of 600 milliliters capacity in which the three-inch squares of steel would stand on the

Alfred Douty

bottom not quite erect, because they would rest against the curved sides of the beakers. In those experiments where the lead strip was to be in contact with the steel, the lead "U" was first placed in the beaker with the arms upward. The steel was then placed resting upon the "U" on the bottom of the beaker and leaning over to one side, and one arm of the "U" was then bent over so as to make contact with the steel square at the top as well as at the bottom, so that the steel square rested on the lead at the bottom and also rested against the lead at the top. Just to complete the record, the experiments were run at 90 degrees Fahrenheit, the beakers were placed in a thermostated air bath and the temperature was kept constant to within four-tenths degrees. The acid used was very close to 15 per cent acid. I record it as 4.37 normal. I started with chemically pure hydrochloric acid. The panels as they came to me were cut out of a piece of tank plate and had their original scale on them. Before starting the tests they were pickled free of scale in acid of approximately the same strength as was used in the test, which took three minutes. They were then washed with water, with dilute tri-sodium phosphate solution, again with water, and then with alcohol, dried and weighed on a chemical balance. The lead strip was scraped clean with steel wool and dipped for one minute into one to one hydrochloric acid, washed in water, dried with alcohol before the test.

In this first test each type of test was run in duplicate and the panels were allowed to remain in the acid under the conditions specified for 15 hours. The panels were then again washed under the tap, scrubbed with a bristle brush under the tap, and washed with dilute alkali, again with water, then with alcohol, dried and reweighed. At the conclusion of the test, the solutions were all analyzed for iron by titration and the loss in weight of the panels was compared with the amount of iron found in the solutions at the end. As an example of the type of results that were obtained, I have expressed the losses in weight as a per cent of the loss, a per cent of the original weight of the

Alfred Douty

panel, because the panels, although they were cut fairly accurately to 3" square weren't exactly of the same size, and therefore since almost the entire area consisted of the large flat sides, the sheet being all of the same thickness, the weight of the panel was closely proportional to its area and therefore the best way to express the results was as loss in weight as a per cent of the original weight. The results are these: When the steel only was exposed to the plain acid the panels lost on the average 2.954 grams—I mean per cent of their weight.

The Court: That isn't grams? A. That isn't grams. That is per cent of the original weight. In other words, they lost about 3% of their original weight. When the steel was touching the lead the panels lost an average of .0172% of their original weight.

The Court: What is that? A. .0172%. In other words, something around 1/200 of the loss in the first case. I want to call to your attention, Your Honor, those were not the actual losses in weight. Those were the amount of iron found in the solution at the end. The amount of iron dissolved expressed as per cent of the original weight.

The Court: Well, is that .0172%—A. (Interposing): That is per cent of the original weight of the panel, Your Honor.

The Court: Before this experiment? A. Yes, sir. In the third case, where the steel was in the same beaker but wasn't touching the lead, the average loss was 1.934% of the original weight of the panel. Now, in the second series of experiments where the acid used was originally saturated with lead chloride, when the steel alone—

The Court (interrupting): Now, let's see. This is the one where you started out. A. This series of 3 tests which I have labeled D, E and F, were all run with acid which was originally initially completely saturated with lead chloride.

The Court: In what per cent? A. It was still the same acid, Your Honor, in strength—15% acid, but the lead chloride at 90° F. in that acid, lead chloride is soluble to

Alfred Douty

the extent of approximately 10 grams per liter, somewhere around that order. In other words, around 1%.

The Court: The second one is going to be saturated in lead to start in with? A. Yes, sir. That is about one per cent of the weight of the solution. The panel where the steel only was present in the beaker lost 1.870% of its weight. The iron dissolved was 1.870% of the weight of the panel. Where the steel was touching the lead, the loss of iron was .243%. I have it here .2426, but I don't think that number means anything beyond about two significant figures, anyway, if that much.

Then the third experiment, where the steel was in the same beaker but not touching the lead, the panel lost 1.409% of its weight. Now those are the averages of two experiments carried out to an absurd degree of accuracy but they are simply what I found. Now, you will notice the significant thing about that test is that comparing experiments A and B in which plain acid the steel was either touching lead or not touching lead, we have only about somewhere $1/60$ times as much attack when the steel touches the lead; in the second case where the bath was originally saturated with lead chloride we have somewhere around $1/9$ as much attack, relatively speaking. In other words, as far as that particular experiment goes, the relative protection was far less when the lead chloride was present.

Now, an interesting thing about these experiments was this—when the panels were observed after the operation it was noticed that those panels which had been in plain acid or had been in contact with acid saturated with lead chloride but which had not been in contact with metallic pieces of lead; they were generally etched, they were dark in appearance, had a loose film of carbon-like smut which easily washed off under the water tap with a soft brush. The panels were slightly rough to the feel, to the touch. The panels which had been in contact with the metallic lead during the immersion were a clean gray in color, they didn't have any smut, and they felt greasy to the touch.

Alfred Douly

Without going into the details, after making a few experiments, and then analyzing the accuracy with which my analyses for iron were made, I found that I could not possibly have made an error in my iron analyses that would have been greater than about two per cent of the amount of iron determined; and for small amounts of iron, I could not have made an absolute error in the amount of iron determined greater than approximately a few milligrams at most. In comparing the actual losses in the weight of the panels with the amount of iron found in a solution, I find that in experiments, A, C, D, and F, the ones where the iron did not touch the lead, the quantities of iron dissolved compare with the loss in weight of the panel in every case, within about one per cent or less. However, in the case of the panels which have been touching the lead strip, it turned out that the iron dissolved exceeded the loss in weight of the panel by a considerable amount.

In the case of the panels in the second test, the average was approximately 95 milligrams; that is to say, that the panel must have gained weight in lead some 95 milligrams. In the case of experiment E, where the lead chloride was present, the average was about 160 milligrams. So that, computing that with the regular density of lead, that would mean that the panels were coated with approximately three to five millionths of an inch of lead.

The next experiments after these were in an attempt to find out why the protection in the presence of the dissolved lead chloride was not as good as it was in the absence of the dissolved lead chloride; and they lead to this conclusion in the second experiment, that is, the second experiments were carried out in approximately the same way as the first, except that I omitted the series in which there was lead in the beaker, but not touching the lead strip; and I left that experiment go on for a total of 96 hours, analyzing the solution at 24, 72 and 96 hours, and at the end weighing the pieces.

And I found that where lead chloride was absent from the solution to start with, gave protection, good protection

Alfred Douty

for the lead which lasted about twenty-four hours and began to break down before seventy-two hours. But I found that in the case of similar solutions in which the lead chloride—the solutions were originally saturated with lead chloride, that the latter failed to give very good protection for more than about twenty-four hours. Even at that time, protection was beginning to fail, and I ascribed that to the fact, which was easily observable, that the junction between the lead and the iron, which was formed merely by gravity, had been spoiled by a growth of lead chloride crystals and the lead had become insulated from the iron. And it didn't occur very much if at all in fifteen hours, but it occurred pretty completely in twenty-four.

So I then set up a third experiment in which, instead of using the system that I have described, I made a small hole in the top of the panel and I hammered the lead through with a hammer, through the hole on one side and bent the strip over on the other side, and hammered it down, kept upsetting the lead and hammering it until I had an exceedingly tight joint, and then bending some in a self-supporting piece which held up the strip in contact with the lead, and then ran the experiment again, for a total, in this case, of ninety-two and a half hours.

In that second case, I found protection, perfect protection was obtained in both solutions which had lead chloride in them to start with and those which did not; for a period of twenty-two and a half hours. Quite good protection was obtained for a period of sixty-eight hours. But that protection was beginning to fail before the end of ninety-two and a half hours, and that the assembly had—the steel assemblies had become loose with the lead so that the contacts were broken. And I was able to conclude from the over-all set up of the experiments the things that I read in the first place, and also that if you don't make a very, very excellent bond between lead and iron you are going to destroy your protection quite soon.

Every one of the experiments, however, indicated that the total iron dissolved was greater where the solution was

Alfred Douty

initially saturated with lead chloride, that is, for those cases where the steel was touching the lead and when it was not. And that persisted for all three of the experiments, particularly—for all three of the experiments.

The fourth experiment was carried out in exactly the same way as the first experiment described.

Mr. Owen: Have you given any figures on the third experiment? A. I haven't given any figures, Mr. Owen. I don't think reading the figures into the record is going to make the picture any clearer. I will give you the figures, and if you think you can—

Mr. Lyon (interposing): They are all in your exhibit? A. All in the report. I don't think reading them into the record adds anything to the picture. The fact is that bonding the iron to the lead gave very good protection. Not as good protection, quite, when there was lead chloride present. And that the protection would last as long as you could maintain the bond. And that the bond had a bad tendency to fail.

Now, my fourth experiment was made in June of 1941 whereas the other three were made in December of 1939. I made this in a considerable hurry, because that was the first time I had heard that copper was supposed to be a factor in this picture, and before I came out here to Bay City I wanted to know how this Menaul effect behaved in the presence of copper. So I set up the thing again exactly as I did in Test No. 1, except not having very much time I simply set up individual pieces, not even in duplicate, under exactly the same six conditions that I have described in the first experiment. The solutions I used were these: I used for the experiment first—for Experiments A, B and C, under the fourth test, plain C. P. acid. For Experiments D, E and F, I used C. P. acid to which had been added, as chlorides, 500 parts per million of lead, five parts per million of copper, and 500 parts per million of iron, which were quantities a little bit larger than the largest quantities reported by the plaintiff here for any of defendant's samples. And the net result of that experiment was to give me results which led to about the same conclusions.

Alfred Douty

That the protection afforded by the contact with the lead was to reduce the attack about 1/160th of its original value, whereas the dissolved metals reduced the attack to about half of its original value. And, the protection afforded by contact with the metallic lead was reduced to 1/50th of its original value instead of 1/160th of its original value in the presence of the dissolved metals, and the absolute amount of iron dissolved from the panel was .0175 grams in the case of the panel immersed in plain acid.

Mr. Owen: Is that grams or per cent? A. That is grams. If you want it in per cent, it was .02 per cent of the weight of the panel, and in the case of the second panel which was immersed in the acid containing the lead, copper and iron, the loss was .0287 grams or .03 per cent. The values are quite small, but curiously enough they accord very accurately with the other small values that I found in the other experiments which compare the loss in weight of the specimens which were in contact with lead when the acid was plain and when the acid originally contained dissolved lead chloride. That was all these experiments were designed to prove, and I think that they show, as far as these conditions go at least, the presence of lead chloride, all the way up to saturation, of lead chloride, copper chloride and iron chloride together in proportion somewhat greater than those specified as the maximum found in defendant's truck tank samples in no way assisted the action of the Menaul system, but actually were detrimental to it.

Q. Now, have you completed reading all your conclusions in Exhibit 299? A. Yes, sir.

Q. As to the actual values that you determined, that is to say the amount of losses, the amount of dissolved iron that you found as a result of these experiments were comparable at all, how do they compare with the values that are set forth in Dr. Bartell's reports as found by him? A. Well, of course my steel samples were not the same as his, nor were they prepared in the same way as his, and yet I would say in general my results accord very closely with Bartell's, where they are comparable.

Alfred Douty

The Court: You get it in percentages, the amount of the solution, taking the reaction in percentages of the weight of the mass of iron, as I understand it? A. Yes, I did that, Your Honor, because the pieces were not identically the same size, and that was the best way you could compare them. The percentage didn't have any reference to rate of attack, except simply to show you how much of that particular piece dissolved during the period of test.


The Court: But it does depend really, what we are really interested in is how much a given surface was attacked, isn't it? A. That is right, Your Honor. However, I gave you the thickness of those panels, Your Honor. They are about 78/1000ths of an inch thick, so if it loses three per cent you can see how much it would lose in thickness.

The Court: Yes.

Mr. Lyon: Now, have you examined Mr. Hathorn's curves, Exhibits 280 to 286, and are you prepared to tell us what they reveal and what significance they have? A. Yes. I have.

Q. First as to the effect on the corrosiveness of the acid in the Menaul tank, what do these curves show or establish in your opinion as to the function served by and the result obtained by the bonding of the lead plate to the steel of the tank? A. I think the curves show very definitely that the connected lead plate greatly reduces the rate of corrosion.

Q. Will you review upon the curves and point out wherein you find such a showing, or find your statement substantiated by the curves? A. Before I begin I want to say that in general I can draw I think five conclusions that have some merit from the experiments which were conducted on what are here referred to as hard steel tanks. As to the experiments conducted on soft steel tanks, I think I am able to draw only one conclusion that I would like to stand on, but we will start with the experiments conducted with these hard steel tanks, which it has been testified are made of the same metal out of which defendant constructs its transportation tanks. Now, by comparing curves 1, 2



Alfred Douty

and 3 of Figure 1, one arrives at a range over which all commercial acid seems to corrode this particular type of steel. In other words, there seems to be a uniformity of experiments—there seems to be a range within which one can expect two experiments to agree (indicating). If we then compare with those Nos. 4 and 5, in which the tank was connected to the lead plate, that again would be a range within which individual experiments may vary. But since the range seems to be fairly well outside the range of experiments 1, 2 and 3, we can conclude that the bonded lead plate has substantially reduced the amount of corrosion going on in the tank. Whenever I say "lead plate," I mean "bonded," unless I say "disconnected," because I now come to the second conclusion, and I wish before going on to the second conclusion to have Your Honor look at sheet 2, DX-281—I was previously referring to DX-280. Now, referring to DX-281,—we have only one result on this chart, namely curve No. 1, for commercial acid alone. We know from examining this exhibit that there will not be any irregularity in the amount of the attack of that commercial acid within a considerable range, but it is also clearly apparent that the installation of a bonded lead plate as shown in curves 3 and 4 certainly gives a marked reduction of corrosion. Now, referring to sheet No. 3, which is Exhibit 282-DX, we can once more compare curve No. 1, which refers to the rate of attack by commercial acid alone, with curves 3 and 4, which refer to the rate of attack by commercial acid in the tank which is furnished with a bonded lead plate.

(Indicating): Now, returning to Defendant's Exhibit 280, which is sheet 1, we find on referring to curves 4 and 5, which are for tanks containing bonded lead plates, when the bond is severed at the end of 24 hours, we know that there is a sharp rise in the rate of corrosion. That indicates with certainty that the lead plate was getting some protection electrically, not chemically, because the solution remaining in the tank at the end of the experiment is the same solution, and this change in slope certainly indicates

Alfred Douty

that electrical protection has a part in the protection. In those two instances, the tank was not cleaned after the disconnection, and therefore it might have been coated with lead or other factors may have—to which I will refer later—may have had a part in the fact that these new slopes are perhaps not identical with the mean of the slopes for commercial acid. However, one can see from these, in the case of curve 4, after the disconnection, one had a rate of corrosion greater than the rate of corrosion of the commercial acid in the plain tank.

Q. Before you go any further I think it would be helpful if you would answer one other question, because you have answered a question as to the effect of the bonded lead plate on the rate of corrosion in the acid in the tank; but so that you can also cover my second question while you are going through these curves, and not have to go through them again, I want to ask you my second question, and that is, what do these curves show or establish as to the corrosiveness of the tank acid after the bond is disconnected? In other words, disconnecting the bond by severing the connection in the tank, but removing the acid from the tank; as compared with the rate of corrosion of commercial acid? A. As I have said, within the limits of variation of the individual experiments, I would say that these curves establish that the acid which had been in the tank system containing the bonded lead tank (plate) was at the end of such a period essentially as corrosive as it was before it had been in that tank. That is likewise well shown in Sheet 2, Exhibit 281, by the change in slope of curves 3 and 4 after disconnection. It is to be noted that in the case of Curve No. 3 the acid was removed from the tank, the tank cleaned, and then put back in the tank again. It is seen that the slope of Curve 3 is not far different than the slope of commercial acid shown in Curve 1.

Q. What does that mean, Mr. Douty, with reference to the acid as it leaves the tank, it is going down the pipe in the well, assuming there is no electrical connection or effect from the tank to the pipe in the well? A. It means

Alfred Douty

that the acid which has been in the Menaul tank for as much as 24 hours is not essentially less corrosive than the acid I put in there in the first place. That once more appears from the comparison of curves No. 1 and 4 of sheet No. 3, Defendant's Exhibit 282, particularly on considering the latter half of curve 4 after the tank had been disconnected. Now, one would expect that at the end of 24 hours acid in such a system would have picked up about as much lead, iron, copper, or any other contaminant as it ever would in any of Defendant's practical tanks.

Now, another indication of the answer to the last question which I just gave, is shown on sheet 6, Defendant's Exhibit 285. In this case, which was run again on hard steel tank No. 1, we have some experiments made both with C. P. acid and with commercial acid to which have been added amounts of iron, lead and copper comparable to those found in the Zahn well, according to plaintiff's evidence. On comparing Curve No. 3, which is the curve for C. P. acid on that chart with Curves No. 1 and 2, which are respectively the curves for C. P. acid to which have been added iron, lead, and copper, or copper alone, we find no essential difference between the rates of corrosion in any of those cases. I would say that all of those curves might well be within the limits of variability of one experiment as shown by curves on previous charts. One curious anomaly is that in curve 4 where lead only has been added to the C. P. acid, the rate of corrosion appears to be considerably lower than curves No. 1 and 2, in which iron, lead and copper and copper alone, respectively, had been added.

Again, I think that the entire range covered by curves 1 to 4, inclusive, is simply a range of uncertainty in this type of testing, one that is to be expected in any type of corrosion testing on this scale. A comparison of curves 5 and 6, which are respectively curves for plain commercial acid and commercial acid containing the three dissolved metals in the proportions stated, shows no essential difference; both might equally have been separate experiments for plain acid or for any one of the acid series we have on

Alfred Douty

the chart. It is probably significant that the commercial acid in both cases, the curve for commercial acid in both cases, lies below those of the C. P. acid.

One more conclusion can be drawn from Chart No. 3, which is Defendant's Exhibit 282. It is to be noted that Curve 2 represents the rate of corrosion of an acid to which has been added one per cent arsenic trioxide. Am I right, one per cent?

Mr. Hathorn: Yes. A. And it will be noted that the rate of corrosion as shown by those curves is of the same order as the rates of corrosion for the experiments in which commercial acid was put into the tank having a bonded lead plate. Now, those are about all the conclusions that one can draw with certainty from the experiments made with the hard steel tanks, which seem decidedly less variable than those made with the soft steel tanks.

I don't know whether it is worth while to point to the experiments in the charts which represent the results on the soft steel tanks, which support the following conclusions: That the corrosion rates under apparently the same conditions are extremely variable. I think that has been already pretty well demonstrated. However, we might look at Curve 4, Sheet No. 4, rather, in Defendant's Exhibit 283, and compare curves 1 and 2. I should say in this particular example the variation between the rates for commercial acid alone, as represented by curves 1 and 2, is not markedly greater than the variation for the other type of steel. On curve sheet No. 5, Defendant's Exhibit 284, we find a rather tremendous variation between the rates of corrosion experienced by tanks of soft steel immersed, or, rather, containing commercial acid with the tank bonded to a lead plate, and that is rather more of a difference than ever appears on the hard steel tanks. We notice in this exhibit that the lead plate does definitely give some protection, and the same thing is visible in Sheet 4, Defendant's Exhibit 283.

The effects of Tergitol are to give throughout very curious and variable results, which can be seen by compar-

ing on Defendant's Exhibit 283, curves 4 and 6. And it is not entirely the only example. Now, we can find only one other significant—one conclusion that really—that is really valid for the soft steel tanks without any question, and that is that one per cent arsenic trioxide gave good protection in every case it was tried. You see that on sheet 4 and we see it again on sheet 5. Curve 8 on sheet 5 and curve 7 on sheet 4.

Q. Would these soft steel tanks, or these curves for those tests, permit a conclusion that the acid from the Menaul tank, after leaving the tank where the disconnection of the bond between the lead plate and the steel, was less corrosive than the acid which was introduced into the tank? A. No; I hardly think it would permit any such conclusion. I think if there is any conclusion at all, I would say that they were inconclusive on the point, on that point. I am speaking now of the experiments with the soft steel tank, that the normal rate of variation of corrosion for the original acid is so great that one cannot draw any conclusions from the slope of the curves after the disconnection of the lead plate. In fact, in most instances, they lie well within that range of variation.

Q. Would you consider that a criticism of Mr. Hathorn's work, or how does it compare with your own knowledge of what results can be obtained in measuring rates of corrosion on soft steel? A. The more corrodable the steel and the higher the rate of the corrosion, other things being equal, the less accurately the corrosion rate can actually be measured. In other words, for a slightly corrodable substance, metal, one is able to get more reproducible results than for a greatly corrodable substance.

Q. That is because the corrosion is going on in greater magnitude and, therefore, being a variable it increases, it magnifies the variation, the result you get, is that correct?

A. That may be one reason; there are probably others that have to do with why metals corrode more rapidly and more slowly, such as the variability of composition within the mass. However, that is a fact that it is particularly

Alfred Douty

difficult to get check results when substances are present which deposit more or less irregularly upon surfaces during the corrosion.

Q. You are familiar with the report of Dr. Prutton in this case. In your opinion is his conclusion justified from that report in the tests reported by him as to the relative rate of corrosion of the Menaul acid after the bond had been disconnected or after the acid has left the system? A. No, I think that generally speaking Dr. Prutton's results simply fail to establish whether or not there was any electrical effect or not. They simply fail to establish it. In fact, the variation of Dr. Prutton's results among themselves have an order which would have permitted of a considerable degree of electrical protection without Dr. Prutton's method having been sufficiently refined to discover it.

Q. Well, do you think it is possible, based on your knowledge of trying to duplicate test results in measurements of the corrosiveness of hydrochloric acid on soft steel to conduct experiments of the kinds that have been attempted here on both sides which would, with any validity, establish or exclude the presence of an electrical effect assisting in protecting the pipe down the well if the connection is made between the pipe and the tank in the Menaul system? A. I am being asked whether something is possible. I do not like to say it is impossible, but I will say that no method that has been mentioned here, at least carried out as anyone has been able to carry it out here, with the best precautions, has been able to establish that one way or another at all.

Q. Now, you are experienced in this matter of electroplating and electrochemical effects as they affect corrosion, are you not? A. Yes, sir.

Q. That is your business? A. I am not—

Q. (Interposing): What is your view as to whether or not connecting the Menaul tank with the well pipe assists in protecting the pipe from corrosion; on theoretical considerations do you think that such protection should be

Alfred Douty

provided by that connection or not? A. I know that protection can be afforded a piece of steel by bonding the lead. I know that that protection can extend to a certain distance, and there are theoretical reasons for believing that it may extend to a great distance. I, therefore, see no reason why protection should not be afforded, at least to some extent, to the well pipe by the Menaul connection.

Q. Have we any method of determining, either theoretically or actually, quantitatively, how far that protection would extend? A. I would hesitate to say that we have a method available. I do not think there is a very easy way to find out.

Q. Well, do you know of any method? A. I do not.

CROSS EXAMINATION

By Mr. Owen:

Q. Will you refer to Table 2 on page F of the data sheets which are in evidence as DX-299 and compare your runs A-1 and A-2 with runs D-1 and D-2? A. Yes.

Q. First, state whether I am correct in my understanding that A-1 and A-2 represent blank runs using C. P. acid? A. That is correct.

Q. And D-1 and D-2 represent runs in which steel strips were placed in a lead chloride solution? A. That is right.

Q. What was the strength of that lead chloride solution? A. I don't know exactly—I know it was far stronger than any amount of lead mentioned in this case.

Q. Well, then, compare the average results of runs A-1 and A-2 with the average of D-1 and D-2, and state what you find to be the inhibition shown in the lead chloride runs as compared with the runs using C. P. hydrochloric acid. You used 15 per cent acid, I understand? A. I did. That has already been done, Mr. Owen, on page K of these results.

Q. What do you find to be that per cent? A. I find that if the attack in experiments A as compared with the

Alfred Douty

attack in experiments D—in experiments D I get about 63 per cent, 62.9 is the figure I have here, 63 per cent as much metal is dissolved in experiment D as in experiment A.

Q. Translating that into terms of inhibition, what would be the inhibition shown in the lead chloride solutions over that of the blanks? A. I presume that the number that Mr. Owen wants is obtained by subtracting 63 per cent from 100 per cent. I can do that, or anybody else can perform that arithmetic.

The Court: You got 63 per cent of what? A. Actually, Your Honor, I found that a certain amount of iron was dissolved in experiment A and a certain amount of iron was dissolved in experiment D, and the amount of iron dissolved in experiment D was 63 per cent of the amount of iron dissolved in experiment A. That means that the amount of iron dissolved in experiment D is 37 per cent less than the amount dissolved in experiment A and I think that is all Mr. Owen wants.

Q. Yes. And the only difference between the two runs was the fact that in the D runs the acid contained lead chloride? A. Yes, sir.

The Court: I don't know. You say the only reason it was was because it contained less chloride? A. Lead chloride.

Mr. Owen: The A runs contained no lead chloride and the D runs contained a saturated solution of lead chloride.

The Court: Yes.

Q. Now, on this page N, run A was the blank. A. Yes.

Q. And what did you use in that, is that C. P. acid? A. Yes. All of these were C. P. acid. This is my second experiment, Your Honor, carried out in the same way as the first, except that it went over a longer period of time.

Q. That test was ninety-six hours? A. Yes, sir.

The Court: That is in the clear acid? A. Run A was with plain acid; yes, sir.

Mr. Owen: And run C had the lead chloride in to the saturation point? A. Yes, sir.

Alfred Douty

The Court: How long did that first HCl plain blank run? A. I think it was fifteen or sixteen hours. Fifteen hours.

The Court: That is the first one that we have talked about? A. Yes, sir.

The Court: And the saturated was the same fifteen hours? A. Yes, sir. All of the runs in test No. 1 were fifteen hours.

The Court: Yes. And now we have got the same thing only it is— A. (interposing): Run over a period of time of ninety-six hours.

Q. Now, will you state how much more iron was dissolved in run A on page N than was dissolved in run C? A. The way the data originally were prepared, the iron loss in run C was 14.09 grams, and in run A 22.27 grams. Run A was blank C. P. acid, and run C was C. P. acid saturated with lead chloride.

The Court: Then we have got two systems of weights here between their way, and now you are injecting another basis, the percentage basis here.

Mr. Owen: That is all we have been dealing with all through the case, percentage of reduction in corrosiveness, and I am trying to translate these figures into the same terms. A. No.

Mr. Lyon: I have been saying here we have just been comparing the actual amounts, or if you are going to try to make it in percentage, they are taking the reciprocal and figuring how many times as corrosive one acid is as another, compared to something in the patent. It doesn't mean—these percentages don't mean anything.

The Court: I am trying to follow both of you. A. Well, Your Honor, did you put down the actual weights lost in the period of 96 hours?

The Court: No, I didn't get the actual weights lost in the 15 hours even. A. Would you like me to give you those?

The Court: Now, here I have a new set of figures. A. Would you like to have me give you those, or have them in

Alfred Douty

proportion? Actual loss in the first experiment on the average was by analysis 2.5—there were two runs, one of them lost 2.586 grams and the other one lost 2.907. Now, they are supposed to be duplicates. Now, panel "C," which were the ones that were in the solution containing lead chloride, this is all in test 1, Your Honor. I am referring to page "G," going back again to test 1, I thought I might as well get all the results in the same form.

Q. Well, "C" wasn't in the question regarding page "F"? A. It is "D."

The Court: I think I understand, I will listen instead of trying to keep any notes on it at all, and I will let my ears serve me. A. Going back to page "N," Mr. Owen, the relative amount of iron dissolved with lead chloride and without is 61.4 per cent over a period of 96 hours. Stating it the other way, there is about 39 per cent reduction or less corrosion in the second case than in the first.

Q. (By Mr. Owen): That is less where the lead chloride was present? A. That is right, over the whole period of 96 hours.

Q. Now refer to page "P-2"; what was that test? A. Now, this test is simply the test made exactly the same as the first test, except that instead of comparing with plain acid, acid saturated with lead chloride, I compared with plain acid, acid containing 500 parts per million each of lead and iron and 5 parts per million of copper.

Q. And in that test, "A" was the blank? A. Yes, sir. And "D" was the acid containing the metals. In both cases the specimen was alone in the beaker.

Q. Well, now, will you compare tests "A" and "D" as to their relative corrosiveness? A. Yes, sir. The actual losses in weight in case of "A" was 2.58 grams; in the case of "D" 1.28 grams. That means that in run "D" almost exactly 50 per cent as much iron was dissolved as in the case of run "A."

Q. And now will you compare run "F" with run "A," stating first how "F" differed from "D"? A. Run "F" differed from "D" only by the fact that there was in

Alfred Douty

the solution along with the iron panel a piece of lead which was not touching the steel, and run "F" the amount of weight lost was 1.08, let's call it, grams, and in that case about 41 per cent as much steel was dissolved as in the case of run "A."

Q. So that putting it the other way about—run "F," with the added chlorides of iron, lead and copper, plus a lead plate which was in the acid, reduced the corrosiveness 59 per cent, is that right? A. It seems to be, yes.

Q. And comparing F and D, the only difference was that F had this loose lead plate in and D did not? A. That is right.

Q. And the difference between those two was about 9% in favor of "F"? That is "F" was less corrosive than "D" by 9%? A. That is right. However, I think if you will refer back to page 6 of my table you will find that the losses in weight do not differ. That is between experiments D and F of the fourth test which you were just referring to, doesn't differ any more than the two individual samples in tests D1 and 2 of the first test. In other words, I would say that difference was entirely within the variation to be expected.

Q. So that you would claim that conducting tests in the manner in which you conducted the ones we have referred to, you can get quick, accurate, reproducible results, do you not? A. Moderately so I can, of course.

Q. Within what per cent would you say? A. Well, that depends on how much attack there is. Generally speaking, I would get more closely agreeing results where there was a lot of some substance which had some restraining effect than where there was less, other conditions being the same.

Q. Then I take it from what you have said this morning that you agree with Dr. Bartell and Dr. Prutton that adding lead chloride to C. P. hydrochloric acid of 15% strength, reduces the corrosiveness of the acid some 40 to 50%, isn't that right?

Mr. Lyon: Now, I object to that on the ground as I

Alfred Douty

remember Dr. Bartell's testimony, and I believe Dr. Prutton's, they stated the lead chloride alone had no more than 12% value.

Mr. Owen: All right, I will pass that.

Q. You show more protection due to the presence of the lead chloride than they did? A. Yes. It may be due to the fact that I used stronger solutions of lead chloride.

Q. Well, what would you say as to your agreement with them regarding the effect of adding around 5 parts per million of copper, lead and iron to a C. P. hydrochloric acid solution, 15%? A. Well, if you will correct that to mean 500 parts per million each of lead and iron and 5 parts per million of copper I would say that my results give relative rates of attack of about the same order of magnitude as Dr. Bartell has indicated on my particular scale under these conditions.

Q. Have you ever run any tests similar to those run by Mr. Hathorn? A. No.

Q. Have you run any large scale tests on this matter concerning which you have testified this morning? A. No, not with any attempt to measure the amount of dissolved iron. I have run large scale tests in the pickling shop where we put through tons and tons of steel and measured the dissolved iron in the acid.

Q. Now, I call your attention to sheet 1 of Mr. Hathorn's curves, DX-280, and to the fact that according to his testimony those runs were made in the following chronological order (you may write them down if you like) 5, 6, 3, 1, 4, 2. Now, referring to the exhibit, 5 was run with commercial acid plus the lead plate and 6 was run with commercial acid plus a lead plate and Tergitol. Now, in view of that fact, what would be your opinion as to whether or not the walls of the tank were coated with lead at the end of run 6? A. At the end of run 6 I imagine there might still have been some slight specks of lead on the walls, but I can't say because the plate had been disconnected. To what extent that lead had been removed, I wouldn't be able to say.

Alfred Douty

Q. Well, at the point where the plate was disconnected, what would you say as to the walls having been covered with lead? A. I would say that, on theoretical grounds at least, and on the basis of what I found, there would probably be lead on the walls.

Q. You do not know what effect the continuing of that run for 24 hours without the lead plate connected might have had on the amount of lead on the walls of the tank?

A. From the course of the curve, I would suspect that lead was being removed fairly fast.

Q. You referred to run 3 which followed run 6, and which was a commercial acid run, and you find that it shows a lower rate of corrosion than did runs 1 and 2, which came later, and which also were run with commercial acid, with no addition. A. That is true.

Q. Now, what would you say as to the probability of some of the lead accumulated on the walls in runs 5 and 6 having remained on the walls during run 3? A. Merely on the face of the curve, in the order you have given me, that could not be excluded. However, after hearing Mr. Hathorn's testimony as to how he cleaned the tanks, I certainly would not expect much lead to be left.

Q. You do notice that run 3 which followed immediately after 5 and 6 with the lead plate in the acid, run 3 showed quite considerably less corrosiveness than did runs 1 and 2, which came later? A. Yes.

Q. Now, the run numbered 1 on this exhibit was a commercial acid run, and shows a high rate of corrosion?

A. Yes, sir.

Q. Run No. 4 followed that, and that was a commercial acid run, plus a lead plate, and it shows considerably higher rate of corrosion than does run No. 5, which is also commercial acid, with a lead plate, isn't that true? A. That is true.

Q. Can you account for that in any way? A. No.

Q. Might it not be accounted for by the fact that the commercial run No. 1, having no lead in the acid, ate up, or dissolved all of the lead from the walls of the tank, so that

Alfred Douty

when run 4 was run it had no reserve protection, and the only protection it got was from the lead plate which was in the tank in run 4. Would that be a reasonable explanation? A. You are entitled to interpret it that way if you want to. I don't think there is any evidence for it.

Q. Have you any other explanation for it? A. No. I don't think I need any.

Mr. Lyon: I think you ought to make a little more complete answer than that. A. After run 1 came run 2.

Q. (By Mr. Owen): Oh, no.

Mr. Lyon: That is not correct. A. Came run 4.

Mr. Owen: That is right. A. And after run 4, in which, presumably since the rate of corrosion was decidedly lower than run 1 which immediately preceded it, one might presume that the tank had once more gotten coated with lead to whatever extent such treatment coats it with lead. Then it was cleaned in the same way as the tank was cleaned after run 5, and we got run 2, and now run 2 isn't—run 2 followed run 4 just as much as run 3 followed run 5.

Q. Yes. And during run 4 the walls of the tank became covered with lead, did they not? A. I think so.

Q. And then run 2, which immediately followed with commercial acid, showed a considerably lower rate of corrosiveness than did run No. 1. A. No.

Q. Isn't that true? A. I don't think so.

Mr. Lyon: Wait a minute. I want to object to the question because the evidence is that between runs—those two runs, the tank was completely cleaned and the witness hasn't admitted and there is no evidence that there would be any lead remaining on the plate following such a cleaning.

Mr. Owen: Mr. Douty, what is your opinion as to the effectiveness of sulphuric acid in dissolving lead?

Mr. Lyon: Plus the reversing of the polarity and the other things that were done in cleaning the tank.

Mr. Owen: Well, now, Mr. Lyon, I would like to conduct my cross examination.

Mr. Lyon: Well, I don't mean to interfere.

Alfred Douty

Mr. Owen: But you do.

A. Well, Mr. Lyon, sulphuric acid is fairly resistant—I mean lead is fairly resistant to sulphuric acid when the lead is there in some appreciable amount, and the reason is unquestionably due to the fact that lead sulphate, the product of the reaction, is quite insoluble. Now, from my experiments, on which some doubt could be cast, anyway, I find that the amount of lead that might be deposited is from three to five millionths of an inch, and I certainly don't think that amount of lead would withstand forty-five minutes to an hour as anode in ten per cent boiling sulphuric acid, besides which, at the end, particularly when the surface was scrubbed with a steel wire brush, it was rinsed with more boiling water, and finally washed with fifteen per cent hydrochloric acid, which is a better solvent for lead sulphate than is water or sulphuric acid, so that the final wash with hydrochloric acid would probably have removed, in my opinion, all of the lead sulphate which might have remained as an insoluble precipitate in the tank. I would say that the chance of there being any appreciable amount of lead in the tank is small. I cannot exclude the fact that there might be traces of lead on the walls.

Q. And that that might account for the fact that commercial acid run 3, which followed some of the lead runs, was less corrosive than commercial acid runs Nos. 1 and 2?

Mr. Lyon: I would like to have the record show that the witness pointed to run 3 at a time of twenty-four hours, and I assume from that he is contending that whatever amount of lead the witness has said possibly might be on the plate would still be affecting the commercial acid after twenty-four hours in the commercial acid.

Q. (By Mr. Owen): Well, maybe the witness knows what that means, I don't. A. Well, irrespective of the interpretation, I think that you would be stretching a point to draw any such conclusion as implied in the question without a whole lot of further evidence. I will say that if there had been lead left in small quantities on the tank

Alfred Douty

wall, which I do not know that that is true, in fact I think it is not, at the beginning of run No. 3 it would have been gradually removed and we would have expected this curve to show an upward trend with time, which it doesn't do, and the reason I assume that is because in general those experiments in which there have been a lead plate connected, which was then disconnected, generally do show an upward trend with time in general after the disconnection.

Q. And you cannot offer any explanation for the differences in the rates of corrosion in runs 1, 2 and 3, can you? A. No, I can't offer any explanation.

Q. Nor can you offer any other explanation for the differences in runs 4, 5 and 6, each of which contained the lead plate? A. Well, I don't know what conclusion to draw about experiment No. 6. The rate of corrosion of that tank over 24 hours was essentially zero. It started out at a value of about 40 ounces per thousand gallons of iron and it ended up at about 56 parts per million, as near as I can read that chart—rather ounces per thousand gallons, as nearly as I can read the chart. Now, it may be the Tergitol had something to do with that, I don't know.

Q. That is, run No. 6, which shows a very low rate of corrosion, was commercial acid plus the lead plate plus Tergitol and it differed from runs Nos. 4 and 5 only in the fact that it contained Tergitol? A. Yes, that is all that appears on the chart.

Q. And that would indicate the Tergitol had an inhibitive effect, would it not? A. No.

Q. What does it indicate? A. If it indicates anything, which is questionable, it would indicate that Tergitol assisted the Menaul action in protection; a totally different story. No evidence that Tergitol by itself has any inhibiting effect.

Q. But the evidence is that when Tergitol is present the inhibiting effect of the lead chloride is increased, is that it? A. No, sir, that hasn't been demonstrated by anything here.

Alfred Douty

Q. How would you account for the fact that with the Tergitol present the rate of corrosion is so much lower than it was in the two runs when it was absent? A. I don't know, I haven't made any great attempt to account for it; I shouldn't be at all surprised if Halliburton could patent that.

Q. Now will you turn to the second sheet, DX-281. In this sheet the order was 1, 4, 2, 5, 3. Now, in this sheet, run 1, which was the commercial acid run, shows the highest rate of corrosion, does it not? A. Yes, sir.

Q. And run 2, which is commercial acid plus Tergitol, shows a considerably lower rate of corrosion? A. Yes.

Q. And run 4, which has the lead plate in, intervenes between runs 1 and 2? A. That is correct.

Q. So that the lowered rate of corrosion in run 2 might have resulted from the fact that the tank took on a coating of lead in run 4, is that true? A. No, I don't think that is true; I mean, I do not say it is untrue, but I certainly do not interpret it that way.

Q. It would be true if it were assumed that the tanks were not thoroughly and properly cleaned, would it not? A. Once more I think not; the general course of the curve for run 2 is concave towards the horizontal axis, rather than convex towards the horizontal axis, as you would expect had the tank had a lead coating on it to start with.

Q. Then the only way that you can account for the lowered rate of corrosion in run 2, as compared with run 1, is the presence of Tergitol in run 2? A. That plus the uncertainty in the exact rates of corrosion, or the lack of complete reproducibility.

Q. Now will you turn to sheet 3, in which the order was 1, 4, 5, 2, 3, and will you here compare curve No. 1, using commercial acid, with the dotted portion of curve No. 4, which indicates the rate of corrosion after the lead plate was disconnected and the tank cleaned? A. Yes, sir.

Q. I understood you to testify that from the point where the lead plate was disconnected in curve 4, the curve showed substantially the same rate of corrosiveness as that

Alfred Douty

in curve 1, using commercial acid? A. Within what I think has already been indicated to be the range of reproducibility I would say that is so.

Q. Well, now, isn't it a fact that if you compare the portions of the curve after the lead plate is disconnected in curve 4, that the corrosiveness in 4 was considerably lower, or substantially lower than that in curve 1? A. Well, it is somewhat lower.

Mr. Lyon: At what point is that?

Q. Take from the 24-hour point the next 20 hours, in both of them, and state what the loss in weight was? A. Well, let's see, taking the first curve No. 4, starting at 24 hours, we go from 19 ounces per thousand gallons up to 159 ounces per thousand gallons, which is a gain of 140 ounces per thousand gallons in 20 hours. Now, do you wish me to compare that for the first 20 hours of curve 1, or with the time from 24 on? I don't know whether that is on the curve or not.

Mr. Hathorn: It is not on the curve.

Q. Take the first 24 hours—the first 24 hours then. A. That starts out with 6; that goes from 6 ounces per thousand gallons to 209 or 203—I think it is 203; roughly about 70 per cent as much corrosion in the hours from 24 to 44, on curve 4, as in the hours from zero to 20 in curve 1.

Q. Well, now, isn't it a fact that the only difference in those two runs in the period you have used for comparison was that commercial acid run No. 1 wasn't preceded by a lead plate run and that the portion of run No. 4 which you have considered was preceded by a lead plate run? A. That is correct. That was the object of the experiment.

Q. Can you account for the lowered rate of corrosion in any other way than being due to the fact that the acid contained dissolved metals in run No. 4 after the plate was disconnected? A. I cannot account for it by any mechanism that I can tell you about but if you turn back to sheet 1 and make the same computation—theoretically the tank should be clean at that point because after the cleaning operation it should be clean.

Alfred Douty

The Court: It was disconnected at that point? A. Then the tank was all cleaned out, the acid poured back into it again.

The Court: As I understand, the point there was he was saying how nearly was this (indicating) parallel with your commercial acid from that time on. A. I say this is about 70% of the slope of that (indicating).

The Court: And now he is asking you if the difference between that isn't due to what was in the acid, and you are answering this was within the range. A. That is correct, and I wanted to prove that by reference to the first chart in which we had two identical runs.

Mr. Owen: Now, referring to curves 3, 4 and 5 of sheet No. 4, DX-283, isn't it a fact that they show practically no break at the point when the lead plates were disconnected? A. That is correct.

Q. They continue right on just as though the lead plate had not been disconnected? A. That is correct. And a curious thing is curve 6 shows a sharp break which should be an identical one with curve No. 4.

Q. Now, turn to sheet No. 5. In this sheet, curves 5, 6 and 7 show no break in slope when the lead plate was disconnected? A. I think you are mistaken about that, Mr. Owen. I think you will find a considerable change of slope in curve 6, for instance, between the early and late parts. I haven't computed what the amount is, but I think it is obvious that the curve has a higher slope. A little hard to see on a curve already so steep, but I think anyone can see, neglecting that slight loop at the end of twenty-four hours and continuing on, that this slope is getting higher and higher, faster and faster, as compared with the lower part of that curve. I think anybody can see that without having it calculated. I may have made some calculation on that. I will see.

Q. Now on sheet 6, this represents runs in hard steel tank No. 1, with copper, lead and iron added to commercial acid? A. Yes, sir.

Q. As I recall, when you referred to this sheet before

Alfred Douy

on direct you stated that you couldn't make any sense out of the curves on this sheet, is that right? A. That is right.

Q. You can't account for them? A. No.

Q. Well, neither can we. A. All I think I said before was that this group of curves, for instance 1, 2 and 3, is that they might be singularly good members of a series that were supposed to be duplicates, where they are not supposed to be duplicates.

The Court: While you are on a different subject, which is one which doesn't show practically anything, I want to ask you, Mr. Owen, are you through with showing from these sheets the curves that you wanted to call to my attention for which you claim that subsequent experiments did not show as great corrosion for the reason, as I take it, you claim they were not thoroughly cleaned. Well, they might be either way, one way, and his theory is that there was a tolerance or range within which one group fell and another lower range within which the other fell, and while they varied a lot there still was enough, and I have got to watch that in the same way again too, but these experiments, some of them, I want a hundred before I reach a conclusion about them, to tell you the fact about it. They are that kind of experiments.

Mr. Owen: And these tests of Mr. Hathorn, there are comparatively few runs under the same conditions, Your Honor. There was no attempt to run two or three of the same kind and take an average.

The Court: Someone tell me how many there are here where the subsequent run went higher than the first one after the cleaning; can somebody tell me that? A. Well, Your Honor, would you mind rephrasing that; I mean do you mean to say—

The Court: Well, now, Mr. Owen has shown here that your first run went higher than your second run, and I take it by his questions that he is inclined to think that the tank wasn't thoroughly cleaned, had lead on the wall of it, and that is the reason why the second run didn't get as high. Now, if you find some of these that go the other way, why,

Alfred Douty

I think that would be very important for me to know, and I haven't any idea about it. I just followed him. A. If I may answer that, Your Honor, I think Mr. Owen's point was this, and if I am wrong Mr. Owen will call me for it. The first run on this sheet No. 1 was No. 5, which was a run with a lead plate in. And that was followed by run 6, another one with a lead plate in the tank. Remember, of course, that the tank was cleaned after each run as well as we know how, as well as Mr. Hathorn knew how. Then after run 6 came run 3. Now, after run 3, which was plain acid, no lead plate, Mr. Owen says, "Now, that one probably represented a nice cleaning operation, merely leaving that acid in there for 48 hours." However, it was all cleaned out over again by the usual method, and then came run 1, Mr. Owen says, "Why did run 1 go so much higher than run 3?"

The Court: Run 1 is just because it is the highest there.

Mr. Allen Owen: It is commercial acid.

The Court: But it was made the last one? A. Yes, of that series, as far as we have gone. In other words, Mr. Owen says that the reason probably that run 3 is lower than run 1 is because it probably had residues of lead from the first two experiments with the lead plate. And he says that is demonstrated by the fact that the next run jumped up a whole lot, and I say it does not prove it at all, because run 2 comes down again; now, I don't know where we are.

Mr. Allen Owen: Run 2 comes down again, Your Honor, because it is subsequent to their lead plate run, which is run 4.

A. Of course run 2 is higher for the first four hours and lower here (indicating), it is hard to say—

The Court: In this talk to me about time now, kinds of runs there, are there any there that the later run is lower.

Mr. Owen: That is where a commercial run followed a lead run, is that what you mean?

Mr. Lyon: Put it this way: is there any there that show the opposite effect of what Mr. Owen pointed out?

Alfred Douty

Mr. Owen: Yes.

The Court: His contention is that cleaning wasn't complete and therefore the subsequent run wasn't as high as it would be?

Mr. Owen: That is right.

The Court: Now, are there any there that go down? I haven't any notion about it at all. A. I will see if I can find them, Your Honor. Do you mind if I consult Mr. Hathorn?

The Court: Yes, both of you look at it, all of you look at it.

Mr. Owen: Put the order on sheet 4.

Mr. Hathorn: 3, 1, 6, 4, 7, 5, 2.

Mr. Owen: We have got mixed up on our order here. I have one order, and Mr. Hathorn has another.

The Court: That kind of restores my loss of egotism. I got almost an inferiority complex here, and had it until I hear the rest of you tell me about some of your troubles, and that kind of restores me.

(Counsel, the witness and others conferred at the chart board.)

The Court: This is a necessary parley, and you haven't proved anything without this. If you come through there and prove something, then I have another question to ask you, just as soon as you make this riveted quite strong—then I am going to ask you another question.

A. In this particular chart, No. 5, the experiments were run in the order of 4, which is plain commercial acid. This was the first one run (indicating) 4. After that came a lead plate, 5, which had a lead plate in it. Then came No. 2, which is up here (indicating). Then came No. 3. That had a lead plate, and also Tergitol. Then it went to No. 1, which did not have the lead plate or the Tergitol. So when this—in this particular instance, the subsequent runs were higher instead of lower (indicating).

The Court: Which is the first one? A. No. 4.

The Court: The lowest one here, of the plain commercial acid, that is the lowest one, isn't it? A. Yes.

Alfred Douty

The Court: What does this do to your theory, Mr. Owen?

Mr. Owen: This is the sheet that Mr. Douty said he couldn't make anything out of, and we said we couldn't either.

Mr. Allen Owen: This one shows no electrical effect in the run which was supposed to have leaded up the tank. That is the only one that Mr. Douty will agree there is no change in the slope? A. I cannot see any break at all there. It looks to me as though that is a general kind of curve there, though (indicating).

Mr. Allen Owen: There is very little if anything left on the side of the tank.

Mr. Hathorn: The lead plate reduced the corrosion, though.

Mr. Allen Owen: I grant you that.

The Court: Doesn't this one disturb your theory, or tend to; in other words, if that were just reversed, you would be citing it to me as another good example (indicating). The next question I was going to ask you, Mr. Owen, was, I take it that this agrees with your theory, but we will suppose it does not, if you had some uniformity—every time the second run went lower, then the results that you claim from that would be that the wall had been coated by the lead plate, which was connected up to the iron in such a way that it prevented corrosion to a certain extent. My next step is, to the extent that it does that, that is without putting any inhibitor fluid that they use, isn't it, to the extent it does that?

Mr. Allen Owen: All we claim for those things is to show the more or less faulty technique that Hathorn used, because his results are entirely unpredictable.

The Court: I say, that would follow right along, that independent of what is in the solution, a lead plate connected to the iron does give protection to the iron?

Mr. Allen Owen: There is no question about that.

The Court: The thing the argument is about is whether by giving that kind of protection it also leaves

Alfred Douty

some of the lead in solution, which, as lead in solution, gives an added protection too.

Mr. Owen: That is true.

The Court: Now, is there any dispute of that by the other side?

The Witness: I dispute it, Your Honor. And I think I have a report in my evidence to prove it.

The Court: You say it didn't result from that? A. Yes, sir.

The Court: But the main thing resulted from the lead connected with the iron? A. That is right.

Mr. Allen Owen: I don't think Mr. Douty disputes that after you take that acid out of the tank containing dissolved lead and then put a steel strip in there, I don't think Mr. Douty will deny the acid was less corrosive than before the lead was put in. A. To the extent the lead could act as a resistance, it would. We cannot deny that.

The Court: That is independent of the other, the electrical action? A. Entirely apart from that. The way I am informed, the defendant sets up a truck tank, puts acid in it, and when they get to the well, they dump it down the well. I have never been down a well, I never made a test on the well, Your Honor. So far as their own truck tanks go, this was done in a laboratory test, never done in actual practice. I claim Halliburton's protection in the truck tank is independent of whether anything goes into the acid or not.

The Court: You claim the lead plate connected with the iron while it is there and so connected gives a protection to the iron in addition to what is in solution? A. No, sir, a protection in the iron which is not improved but, according to my experiments, actually is impaired by any lead in solution.

The Court: But you do claim that lead plate connected with the iron is giving protection to the iron of the tank independent of whether there is any lead in solution in the acid or not? A. That is right.

The Court: That is their claim and you don't deny that, as I understand it?

Alfred Douty

Mr. Owen: Our contention is somewhat different from Mr. Douty's. We claim the main protection is from the lead chloride in solution and that the connecting of the lead plate may add something to it, and I think, as I understand—

The Court (interrupting): And if I had succeeded in this of showing that they were all that way, and convinced that always in the second one would add so much lead on by the first they didn't get it all off by this, would be just additional proof of that thing. Of course you were attempting to prove another thing but by doing that you would be proving the extent to which this lead plate connected with the iron did put a coating on the iron which protected it, which you are not complaining about under your patent and have no right to claim anything.

Mr. Owen: No. What we claim is that the lead, copper and iron which are in solution in the acid when it leaves the defendant's truck tank are the effective inhibitors in defendant's process.

The Court: Well, all right. But I think this proof brought out in the discussion does help to analyze this problem.

Mr. Owen: Now, I have just one more sheet of these drawings that I would like to ask Mr. Douty about.

The Court: I think it is very proper, and helpful, this discussion—we can't tell who it will help—but it does help in the understanding about it.

Mr. Owen: Now on sheet 7 will you compare curve No. 1 which is the C. P. acid run with Curve No. 5 which is a C. P. acid plus lead, iron and copper run at 10 hours, and point out what the amount of iron dissolved in each of those was at that point? A. Well, the C. P. acid containing lead, iron and copper, according to this test, at ten hours contained 210 ounces per thousand gallons of iron, and the plain C. P. acid contained 462. 210 and 462 are the two numbers. The blank is negligible in this particular run.

Q. Now, what is the difference in corrosiveness of those two solutions? A. Well, apparently, as expressed by the two numbers, which I have just read, 210 and 462.

Q. And would that show that the acid containing the copper, lead and iron chlorides is about 54 per cent less corrosive than the one without those metals? A. That sounds about right. However, I also call to your attention curve No. 3 in which a commercial acid containing no added metals whatsoever is also far less corrosive than the C. P. acid.

Q. Now, will you compare that curve No. 3, which is commercial acid, with curve No. 6, which is commercial acid plus iron, lead and copper? A. Commercial acid containing the lead and copper at ten hours dissolved enough iron to give an iron concentration of 151 ounces per thousand gallons, and for the plain commercial acid the number was 250.

Q. What reduction in corrosiveness does that show for the acid which contains the metals? A. Oh, roughly forty per cent.

The Court: Let me understand, and let me know clearly now whether or not that one where we found a reversal of the situation, namely, where the test with the clear acid without any lead having been previously used was more than that after the lead had been used, and the plate was cleaned, the reversal of it, was it on that sheet that both sides have said couldn't be made use of, or was it the other?

Mr. Owen: I think it was another sheet.

The Court: I want to get that clear. Which one was it on? A. In justice to these curves, I must say that one of those sheets out of which I said it is difficult to draw conclusions was the sheet No. 7 here, from which Mr. Owen has just asked me to draw a conclusion.

The Court: Which went the other way. A. Surely.

The Court: I know it. But I want to make it clear that here is one with decidedly the opposite results that nobody has contended for that purpose. A. That is right.

Mr. Owen: I believe I asked you a question as to what inhibitors or acid regulators or pickle control substances the American Paint and Chemical Company were manufac-

Alfred Douty

turing when you went with them? A. I have been thinking that question over during recess and I recall that when I became connected with the American Chemical Paint Company Mr. Gravell had tested a number of things and had finally found that bone tar oil, mixed with sulphuric acid, gave a product which was a reasonably efficient pickle control substance, and that is about as far as he had gone. Whether any of that had been used commercially at the time I joined the company, I don't remember, but some of it was used commercially shortly thereafter, I am sure.

Q. And that would be the first one, at any rate? A. Yes, sir.

Q. Will you tell us what that was, how it was made? A. I don't remember the proportions, and I haven't the formula with me, but it was made out of concentrated sulphuric acid and bone tar oil. It was a very unpleasant material to make and unpleasant material to handle, an evil odor. It was called "Rodine."

Q. Well, what is the name and formula of the first product your company made and sold as a pickle control substance or acid regulator? A. The first one I can find in the formulas of the company, and, therefore, it is the first one that I am sure that was used commercially, is known as "Rodine extract," and appears in our formula book as formula No. 71, under date of December 1, 1923. Now, I have reason to believe that there was an earlier formula for that, which probably didn't get into this formula book, because I find immediately preceding formula 71, a formula, No. 70, of the same date, which refers to "Rodine extract." However, since they were written on the same date, I am not sure that it wasn't referring to the same product.

Q. Which of them was manufactured and sold? A. Rodine extract was certainly manufactured and sold.

Q. What is the formula of the product that was manufactured and sold? A. The formula is very similar to the formula given in the Gravell patent in suit, at the top of the first column of the second page, except that it does not contain any arsenic.

Q. Well, then, it would be the formula which appears at the bottom of the first page, wouldn't it? A. Yes, that is very close to it.

Q. I wish you would explain just how that product was made. A. I will read the formula sheet here. It has directions. At the top of the formula sheet it says, "Tar oil," which means bone tar oil, ".476 gallons. Hydrochloric acid, .727 gallons." Mr. Gravell has here in parentheses after hydrochloric acid "1.200," but I know that we never had any commercial hydrochloric acid of that gravity, and he must mean 1.160, which is the gravity of 20 degree muriatic acid. We never had any 22 degree muriatic acid in the place. So that is really about 31 per cent hydrochloric acid. The official table of specific gravity of hydrochloric acid solutions, adopted by the Manufacturing Chemists Association, gives for 1.200—that would be 24.2 degrees Baume. Well, now, there isn't any such hydrochloric acid commercially. The strongest one we have ever had in the plant would have a gravity of 1.160, which is 20 degrees muriatic acid, and that was what was actually used, and that is 31.45 per cent HCl.

The Court: And there was .727 gallons of it? A. That is right, sir, of 20 degree Baume.

Q. Now, assuming that that formula called for 20° Baume hydrochloric acid, what was the proportion appearing of hydrochloric acid in the product? A. The total hydrochloric acid in the product would have been something like 20, 23, to 24%. But, of course, some of that hydrochloric acid would have existed there as salts of the basic materials in the tar oil.

Q. How much do you assume would have been consumed in neutralizing those salts or neutralizing the basic material in the tar oil? A. The tar oil consisted of approximately one-half basic material. That would have meant that there would be about 200 grams of tar oil bases per liter of product and the average molecular weight of those bases would have been somewhere in the neighborhood of 300. Therefore, about two-thirds normal hydro-

Alfred Douly

chloric acid would have been sufficient to neutralize them and the acid actually used was approximately 7.3 normal. So that I should say about 85 to 90% of the hydrochloric acid I have mentioned would still have remained free. So there would probably have been somewhere between 15 and 20% of free hydrochloric acid in the product.

Q. Now, will you explain the process of making this product which is shown in the formula at the bottom of page 1 of the patent and just explain it in some detail, please? A. I will read the directions on the formula sheet, written in Mr. Gravell's style of typewriting—"The tar oil is first placed in the agitator and the hydrochloric acid while stirring. Considerable heat will be generated. The agitator should be covered and connected to a chimney to take care of the vapors evolved. The agitation should be maintained for approximately 1 hour, and then the admixture should be allowed to settle for twelve hours when it will be found that it has separated into two layers, with a contraction in volume of .013 gallons. The bottom layer consists of Rodine extract and will measure 1.00 gallon in volume, and the top layer will consist of oil and will measure .19 gallons in volume, as shown in the following table," and the figures are retabulated showing the loss in volume and oil separated.

Q. And what is the pickle control? A. The bottom layer is Rodine extract.

Q. And what proportion is that of the whole? A. About a little over eighty per cent.

Q. Then the product that was actually shipped was this bottom layer with the hydrochloric acid that had been taken up in the process of manufacture; is that right? A. Yes. All the hydrochloric acid remained in the bottom layer.

Q. And what was the purpose of using the hydrochloric acid in connection with that bone oil extract, or that bone oil, rather? A. To extract the basic materials from the bone oil, which basic materials were the active inhibiting ingredient, and hold it in solution. There was

Alfred Douty

also a secondary effect which is not particularly important here, except that it is a curious fact that small amounts of hydrochloric acid have an inhibiting effect when added to sulphuric acid, so that there was a deliberate use of an excessive hydrochloric acid here because it increased the inhibiting effectiveness of the material.

The Court: And by that you mean inhibiting as to eating iron? Reacting with iron? A. That is right, sir.

The Court: Hydrochloric acid on sulphuric. Sulphuric itself is corrosive. A. Yes.

The Court: And will react with iron, but you put in a little bit of hydrochloric, which in itself and alone will eat iron and that combination is less corrosive than either one of them? A. That is correct. I found a reference to that in some of the journals I have read in preparation for this case. In fact, in some of the references which the plaintiff has cited.

The Court: In other words, they find in themselves some satisfaction that is exhausted for their reaction with iron; they take it out on each other. A. Apparently.

Mr. Owen: That product you say was called Rodine? A. Rodine extract.

Q. And it was sold and used in what way, for what purpose? A. The only purpose that I remember Rodine extract ever having been used for is as an adjunct to the pickling of steel articles.

Q. It was put in the pickling bath? A. Yes, in small proportion, of the order of one-half to one per cent of the concentrated sulphuric acid, which was a constituent of the pickling bath.

Q. How was it shipped? A. In glass carboys.

Q. Now, what other similar product, if any, was made and sold by the American Chemical Paint Company shortly after you went with them? A. The next product that appears in the book was Rodine No. 3, which bore our formula number 85 and the date June 18, 1924. And that consisted of a material very similar to the previously named material, except that an effort was made to remove

Alfred Douty

a certain amount of tarry substance that was likewise dissolved by the concentrated sulphuric acid from the tar oil, and which was objectionable in the pickling operation because it had a tendency to leave spots and deposit on the pickled metal.

Q. Was it made in the same way as the other Rodine you have previously referred to? A. The final proportions were essentially the same, but the method of manufacture was a little different in that the extract was first made as before and separated from the waste oil and then the extract was treated with alkali so as to throw out the free bases, and the free bases were redissolved—or, rather, let me put it this way: the extract was made which was somewhat more dilute than previously made, so that it wouldn't take up so much tar and then the bases were liberated from the extract and redissolved in hydrochloric acid in essentially the same proportion as before, so as to have a material that made a nice clean water solution without tar to go in the pickling bath.

Q. And was the final product about the same, you say? A. Yes, very nearly.

Q. Same proportion of hydrochloric acid? A. Yes, it had, I see by the book, .753 gallons of hydrochloric acid in a gallon of finished product, whereas the other one had .727. It had a trifle more hydrochloric acid in the finished product. It worked the same as before.

Q. What was the number of the next formula? A. The formula that I just read to you, Formula No. 85, has a notation on the top of the page, in Mr. Gravell's handwriting, "Discarded, see Formula No. 92."

Q. That is, the one that you have just referred to, was discarded? A. Yes. You can see here, we have, curiously enough, Formula No. 90, and this is also marked discarded for Formula No. 92. Formula 90 appears on October 29, 1924, and Formula No. 92 is on November 12, 1924; so that the material of Formula No. 90 apparently was short-lived in our formula book, and was immediately replaced by the November 12, 1924, material, and that is

Alfred Douty

the material Formula 92 on which Mr. Gravell has written "Standard."

Q. How was that made? That is, how did it differ from the other? A. May I state that before Formula No. 92 became standard, the October 29th Formula No. 90 was made exactly the same as Formula No. 85, except that a solution of arsenous oxide was added to it, and that was also added in the case of Formula No. 92, which is the standard material of November 12, 1924.

The Court: From what you have given me, I have the notion that 85, and 90, were probably in their day standard, and that this pencil mark simply is the result of some day, we don't know just when, he just marked that, as the standard? A. Very likely, Your Honor, he was revising his formula book on that day, and he went through these formulas and said, these are discarded, and this one is the standard one, on that date, whenever it was.

Mr. Owen: Now, going on with your products, what was the next product put out, or that you say will comply with the formula at the top of page 2 of the Gravell patent? A. The next product which would approximately correspond to the formula at the top of page 2 of the patent was Rodine No. 2, treated, our Formula No. 105, of date April 6, 1925.

Q. What were these other earlier Rodines called by number? A. No. 3 preceded No. 2. Formula 92 was No. 3 Rodine and Formula 90 was No. 2 Rodine, and Formula 85 was Rodine extract; no, that was also Rodine No. 3. That goes all the way back to the first one I gave you to get Rodine extract, that is 71.

Q. How did this Rodine No. 2 differ from No. 3? A. It appears to be very nearly identical with it. For instance—(after examining document)—oh, I wish to make one correction in my previous testimony. I overlooked the fact that in Formula No. 90, .508 gallons of bone tar oil was used to make a gallon of finished product. In Formula No. 92, only .320 gallons was used. In other words, that was somewhat weakened for some commercial reason or

Alfred Douty

other. I do not think that Rodine No. 3 was sold over a very long period, because I see there on April 6, 1925, we had a formula for Rodine No. 2 in which once again almost a half a gallon, namely, .496 gallons of bone tar oil was used for making a gallon of finished product. So we seem to have restored the strength again, and made it under Rodine No. 2.

Q. It is your opinion that Rodine No. 3 was not sold very much? A. Well, it probably was not sold much beyond the early part of 1925. I did not mean to imply that there was not much of it sold there. I meant simply to say that it may have been extensively sold during that period, but the period during which it was sold at all was not very long. I cannot give you any figures at all as to the sales of this material, Mr. Owen.

Q. You don't know whether it was extensively sold, or only slightly? A. I cannot tell you. I have not got any sales figures.

Q. Well, then, your No. 2, appeared when? A. April 6, 1925. Now, it is curious that formula 105 which appeared on that date has Rodine No. 2 and then, in parenthesis, treated. There is nothing in the formula books here to tell me but I am almost certain that what they meant was that what was in this book as Rodine extract was for a very short time known in the company as Rodine No. 2, and this Rodine No. 2 which is marked treated, is the one which superseded that. Therefore, since we had never had an official Rodine No. 2 in the book we now started over again with Rodine No. 2, which is really subsequent to Rodine No. 3.

Q. And when did Rodine No. 2 disappear? A. Rodine No. 2, I don't think has disappeared yet. Rodine No. 3 disappeared.

Q. Referring to the formula at the top of page 2 of the Gravell patent, first column, has your company ever made and sold a similar solution using a metal other than arsenic? A. No. Not unless you include gelatin among the organic bases, and there is some doubt about that.

Alfred Douty

Gelatin was used in a material that we made which included gelatin and stannous chloride. I think it was Rodine No. 6. It was used in pickling baths. Sulphuric acid pickling baths, largely.

Q. What is the nearest thing you have manufactured and sold, that is, the nearest to this formula at the top of page 2 in which a metal other than arsenic was used? A. It is pretty hard to say what is the nearest thing. We sold the mixture I referred to which contained tin as a solid, as I recall. At a considerably later date, we sold the material called Murodine. That would be somewhere in probably 1935.

Q. And how did that differ from your Rodine No. 2, for instance? A. That was based on the patent of Saukitis if I am not mistaken, patented some time in 1937 or '38, and it was for a combination of copper with certain organic materials as an inhibitor in hydrochloric acid. That was 1936. The Saukaitis patent is dated August 4, 1936, No. 2,049,517.

Q. What was the formula under which Muridine was made? A. I prefer not to give you the formula in detail, but it contained copper chloride and certain complicated organic bases made by reacting aldehydes with amines.

Q. Did it have any hydrochloric acid in it? A. Yes.

Q. You gave the formula in your deposition, did you not? A. I think I did, or at least I gave you certain parts of it.

Q. I call your attention to your testimony on page 107 of the depositions taken in January, 1941, and ask you to look that over, and the subsequent pages, and see if you can give the formula for Murodine? A. Well, according to the deposition,—and I was reading from the formula at the time I testified—Murodine No. 101 is the one I am speaking of—it contains about fifty per cent by weight of a complicated reaction product of aldehydes and amines, and another active ingredient of an organic nature which I have here forgotten, and some copper chloride, and you asked me at that time, Mr. Owen, how much hydrochloric

Alfred Douty

acid was in the final product and I stated from the formula it was very close to eighteen per cent by volume of twenty degree acid, which would make it run about, say, five or six per cent of hydrochloric acid,—of hydrogen chloride.

Q. How much copper chloride was in that? A. About six-tenths of a pound per gallon, that is six-tenths of a pound of copper chloride dihydrate.

Q. How does that amount of copper chloride compare with the amount of arsenic trioxide in the formula at the top of page 2? A. The formula at the top of page 2 contains .125 pounds of arsenic trioxide and this contains .60 pounds of cupric chloride dihydrate. The arsenic computed as metal in the formula of the Gravell patent at the top of page 2 is .085 pounds in a gallon. Now, the copper in Murodine No. 101 is .226 pounds of copper per gallon.

The Court: The arsenic is less than the copper? A. Yes, sir.

Mr. Owen: Do you consider that this formula for Murodine 101 is substantially the same as that at the top of page 2, column 1, of the patent, except for the substitution of copper chloride for arsenic trioxide? A. It has a rough resemblance; I should say it is somewhat similar. The object of the copper in that formula, however, is not to make the material shipable in steel. We want the copper in there when the customer gets the material.

Q. Does the presence of the copper in Murodine 101 make it shipable in steel? A. Yes.

Q. Do you ship it in steel? A. No.

Q. How do you ship it? A. Glass or wood.

The Court: What is the purpose for your customer's use? A. That was designed for use in oil wells.

Mr. Owen: I am going to ask what your customers use Murodine for? A. It has been used in a number of applications, notably the cleaning of steel equipment which has lime scale on it, by means of hydrochloric acid. We sell hydrochloric acid which contains a certain percentage of Murodine as a material called chlorodine, which is used for cleaning out automobile radiators, boilers, and things of

Alfred Douty

that kind, but we had hoped to sell the largest amount of that stuff in the oil well treating industry, and we did sell some for quite a while.

Q. And you did sell some of it to The Dow Chemical Company, did you not? A. Yes, sir.

Q. And you shipped it to them in wooden barrels? A. That is right.

Q. You also sold some of it to the Halliburton Oil Well Cementing Company, didn't you? A. I am not sure about the Halliburton Company, Mr. Owen. I don't know whether we sold them Murodine or didn't. Mr. Spruance may have said we did. I don't know. I know we sold to the Dow.

The Court: As I understand it, if this patent of defendant's is any good, you have been infringing that if you shipped it to Dow in steel containers? If their patent is good? A. It is our patent, Your Honor, so we never gave any worry about that.

The Court: Oh, it's your patent. That is right. A. It used to be our patent until we sold it to Halliburton a few years ago. I think we have a license from Halliburton to use it in our own business.

Mr. Owen: Now, have you ever manufactured and sold any product other than Rodine and Murodine which corresponded to the formula at the top of page 2, with the exception of the metal used? A. No, I think not.

Q. Now, among the products which you have thus far named, which have had the largest sale? A. In gallons, Deoxidine. I don't know about the dollars. But the Rodine and Deoxidine have been the largest selling materials made or shipped under the Gravell invention.

Q. And the Deoxylyte has been a small seller? A. Not small, but it has been decidedly less than the other two.

Q. And the Murodines, where do they stand in the scale of volume? A. Murodines have been comparatively small sellers, and about the time we were about establishing a nice business in that respect, Dow stopped us.

The Court: By this suit, you mean? A. Well, by writing us a letter warning us not to sell the materials for use

Alfred Douty

in oil wells, and warning us of the existence of their patent and so we tried to sell the inhibitor to Dow and did so for a while, and then they ceased to purchase from us and that was the last time we supplied inhibitors for oil wells.

Q. Do you recall whether in that letter the Dow Company told you you could sell to their licensees as well as to them? A. I don't, Mr. Owen. No, I don't. I have the letter. I have seen it. But I don't remember that.

Q. So that your sales of products which you understand to come within the Gravell patent have consisted of Rodines, Murodines, Deoxidine and Deoxylyte, is that correct? A. There are two other minor products, one of them known as Murodine—no—Clorodine, which is hydrochloric acid to which has been added substances, including arsenic, plus arsenic; and then that other material to which I made reference a little while earlier, Scalolene, which is used, which was used for a while in removing contamination from glass molds.

Q. Well, all of these products which you have made and sold under the patent have been products which contain acid as one ingredient of the product, is that right?

A. Yes, sir.

Q. And in the phosphoric acid solutions—that is Deoxidine, Deoxylyte, the percentage of phosphoric acid is high, is that right? A. Yes, sir.

Q. And in the others, the Rodines and Murodines, the percentage of acid is low? A. Relatively.

Q. Well, it is down around 15 or 20% isn't it, of the solution? A. Well, not these Rodines, it isn't.

Q. How much hydrochloric is contained in your Rodines, your Murodines, or any other products made under the patent? A. Well, I have already given you the figures on several products. Rodine No. 2, which corresponds very closely to the material at the top of the column I think I calculated this morning that that would have had between 15 and 20% hydrochloric acid in it. That is of hydrogen chloride.

Q. You never have undertaken to ship acids for gen-

Alfred Douty

eral use as acids under this patent, have you? A. Only one acid. Phosphoric acid.

Q. And that is this Deoxidine and Deoxylyte? A. We have called that Deoxylyte and have shipped it as inhibited phosphoric acid for several special purposes.

Q. Is that used for some purpose similar to the Parker process or any of them? A. No, these inhibitors are very deleterious in a process like that. They interfere with the action that is necessary to get your rust proofing on the steel.

Q. None of your products are shipped as acids, are they? A. No. They are not just shipped as hydrochloric acid, sulphuric or phosphoric acid.

Q. I show you an exhibit which was identified in connection with Mr. Spruance's testimony as Spruance Exhibit 7, and ask you if that is the label you place on these products when they are shipped? (Handing same to witness.)

A. If Mr. Spruance said so, it is. That is an official label. The regulations of the I. C. C. require you to place such a white label on certain products.

Mr. Lyon: I was going to ask Mr. Owen that Mr. Spruance's deposition be received in evidence with all its exhibits, but ask it be considered read. I didn't think there was any special point in reading it, taking up time to read it.

Mr. Owen: That is agreeable to me. Either party can refer to it as they like.

The Court: Have you the letter here? A. I don't know exactly the answer to your question, Your Honor, but I have a letter here which gives me some dates. The first sale of Murodine made by the Thompson-Haywood Company of—Haywood Chemical Company, of Tulsa, Oklahoma, to Dowell, is reported here as being made in 1935, but sales may have been made earlier than that.

The Court: When did you quit? A. We quit selling to Dow in 1937, January 16th.

The Court: Well, but did you quit selling to anybody? A. No, sir, we still sell Murodine in comparatively small

Alfred Douty

quantities for use in cleaning out water jackets of engines and radiators and boilers.

The Court: You quit for wells, did you, at that time?

A. That is right, sir.

The Court: What amount of business was that, about, that you stopped, can you tell me? A. I haven't any idea, but I think it will appear in Mr. Spruance's deposition.

Mr. Owen: In shipping these products you have referred to, are they sealed or unsealed during the shipping operation? A. Sealed.

Q. Do you store them in stock? A. Yes, we store them. Not usually tightly sealed. We usually leave the bung loose when they are standing out in the hot sun which they generally are; they are generally stored in a yard.

Q. If you store them inside, you tighten the bung down? A. Ordinarily.

Q. Now, I show you three labels which were produced and identified in connection with your deposition, one of these marked Plaintiff's Douty Exhibit 1, and another Plaintiff's Douty Exhibit 2. Those are both Murodine labels, No. 101. Can you tell what the difference between those labels is? Why the two of them have different dates or what— A. Yes, the first one was printed in 1934 and the other one in 1940, to start with. In 1934 we had only one patent on there, namely a patent to a man named Chamberlin, I think, which we own. That patent was the only patent we had on the material at the time. It says on there "Other Patents Pending." It turned out that I found another patent that should have been on that label, which wasn't another patent of Chamberlin's. Then, in addition, it bears the Saukaitis patent number.

Mr. Owen: I will offer the earliest Murodine label as PX-306.

(Whereupon the label was marked PX-306.)

Mr. Owen: Now look at this Exhibit 306 and read into the record the patent number or numbers appearing thereon. A. It says Patent U. S. A. 1,719,649 Other Patents Pending. That is a patent to Chamberlin.

Alfred Douty

The Court: That was a formula patent? A. Yes, a patent for a certain kind of an inhibitor.

The Court: The ingredients that went into it? A. Yes. A certain type of reaction process it was.

Mr. Owen: That was a process patent? A. I am not sure. I don't think so. I am only testifying from memory. You have all the patents.

Mr. Owen: I offer the later Murodine label as PX-307. (Whereupon the label was marked PX-307.)

Q. Please read into the record the patent numbers appearing on this PX-307 and state who the patentees are and what they refer to. A. U. S. Patent 2,049,517—that would be Saukaitis patent. The next one—Patent Canada 1937—and that is doubtless the Canadian patent corresponding to the Saukaitis U. S. patent. And then it says For Use in the Processes or Solutions of the following patents—U. S. numbers 1,719,168 and 1,719,649. Those are both Chamberlin patents.

Q. You don't find the Gravell patent in suit on either of those labels, do you? A. No, sir.

Mr. Owen: I have another label here for Rodine, which I will have marked PX-308.

(The label referred to was thereupon marked PX-308.)

Q. Will you read into the record the patent numbers appearing on that label, and state what they cover? A. This label is for material known as Rodine. It was Rodine liquid No. 102 for muriatic acid. That material did not retain the name "Rodine" No. 102 very long. It is now known as Murodine 102, and it consists of a solution of organic inhibitor. It is not acid, and, therefore, it could not have the Gravell number on it. However, it is Chamberlin's patent number, U. S. Patent 1,719,168. It also says, "Other patents pending."

Q. Do I understand from your last answer that you consider the Gravell patent to cover only acid solutions? A. Certainly, materials for use in acid solutions, such as the composition described in claim 7.

Q. The Gravell patent does contain several compositions of matter claims, numbers 5 to 8? A. Yes.

Alfred Douty

Mr. Owen: How long, in your opinion, Mr. Douty, if you were going to ship acid or if you were going to store it, that is, a corrosive acid, what life would you expect to obtain from an oil drum, in order to consider it a safe procedure, to store or to ship that acid in such a drum. A. The answer to that is the same as the answer of the famous mechanical engineer to the question "Is a boiler safe?" It is safe if it doesn't blow up.

Q. How would you find out whether or not these drums were safe or not, try them out and if they blew up they wouldn't be safe, and if they didn't blow up they would be safe; is that the idea? A. Pretty near. But one could do better than that. You can screw a pressure gauge into the bunghole and find out when the pressure got excessive, over a course of time.

Q. What would you consider to be excessive pressure so as to render it unsafe to store or ship a corrosive acid in a steel drum? A. Any pressure which exceeded or approached the calculated safe strength of the drum. I have mentioned pressure because, you don't mind my explaining this, I mentioned pressure because the product of reaction of the acid with the metal is hydrogen, Your Honor, and hydrogen is a gas, and if it accumulates in the small space above the liquid until there is an excessive pressure, the drum would explode.

The Court: I supposed when you started you were inquiring about how long before it would eat through. Safe in that direction. A. It isn't safe; it doesn't have to eat all the way through.

The Court: But that is what you were asking about?

Mr. Owen: I am trying to get an idea of what would be a safe drum in which to store or ship the acid.

The Court: Well, what did you have in mind, whether the acid is going to eat a hole in it, or whether it is tight enough or strong enough, or what?

Mr. Owen: Well, I should say that there are two possibilities, and one would be that the pressure would blow the drum up, and another one would be that the acid corroded through.

Alfred Douty

The Court: This is the first I have heard about that blowing up business.

Mr. Owen: What would be the effect, Mr. Douty, if you placed a corrosive acid in a drum and closed the opening to the drum tightly? A. Well, if you filled the drum pretty near full when you started, which is the custom, in other words, a drum might hold, level full, fifty-three and a half or fifty-four gallons, and you put in fifty two gallons of liquid, that leaves a comparatively small air or gas space. Therefore, it doesn't require the introduction of a great deal of gas from whatever source to build up the pressure, and in the most cases long before the drum was eaten anywhere near through you could notice the ends of the drum, which is made like a barrel with flat heads, begin to bulge.

Q. And that would be a danger signal, do you think?

A. It certainly would.

Q. What would you expect to happen? A. I would expect if you let it go long enough, that something would let go somewhere.

Q. It would blow acid all over the place? A. It certainly would.

Q. If a corrosive acid were placed in a drum for shipping in interstate commerce, such products, for instance, as you may have, how long would you expect would be a safe time to allow for that drum to hold? What would you think would be a margin of safety so that the drum would not be likely to blow up in transit or after it reached its destination and was stored temporarily until the purchaser wished to use it? A. That is hard to say. We have shipped many drums of material to Europe, acid material in steel drums; we have shipped it to India, to Indo-China, to Australia. We have shipped them pretty well all over the world, and some of those voyages are fairly long.

Q. Several months? A. I think several months would be a representative figure as to a maximum.

The Court: Any trouble with any of them? A. Yes.

The Court: Did some of them blow up? A. No, sir, not ordinarily. I do not think we ever had one blow up, that I recall.

Alfred Douty

Mr. Owen: Were those acids? A. Yes, sir.

Q. Or acid solutions? A. Well, we always used solutions in that sense, if they were not labeled acids, or some other name—

Q. Oh, Murodines, Rodines, and things like that, is that what you refer to? A. Those and the Deoxidine and the Deoxylyte.

The Court: When the hydrochloric acid eats iron, then the gas that accumulates is hydrogen? A. Correct.

The Court: Just the same as when it eats the rock formation, it is carbon dioxide? A. Yes, Your Honor.

Mr. Owen: Which one or ones of your products have you shipped on these long voyages? A. I have no records before me, but I fancy about every product that you ever heard of has gone on a long voyage.

Q. In those products which have been shipped in steel you used arsenic, did you not? A. Always.

Q. You never shipped any product on such a long voyage that did not contain arsenic? A. Correct. That is, in steel.

Q. Now, what is the practice of shipping sulphuric acid in steel? I don't mean by you—I mean general practice, if you know. A. Concentrated sulphuric acid is commonly shipped in steel, steel tank cars.

Q. And what do you mean by concentrated sulphuric acid? A. Sulphuric acid of 60° Baume or over. I think 60° Baume corresponds to—well, I will look it up—that is the weakest acid that is commonly shipped in steel. (Witness refers to records.) That is 77.67% sulphuric acid.

Q. That is, Mr. Douty, 60° Baume is 77.67%. A. Yes, that is right, per cent sulphuric. H_2SO_4 is 77.67%. As a matter of fact, Mr. Owen, most sulfuric acid is shipped at 66° Baume, where it is 93%. It is not commonly considered safe to ship 60°.

Q. It is considered safe to ship 66° Baume sulfuric? A. Yes, sir.

Q. And what is the per cent? A. 93%.

Q. And that has been true for many, many years,

Alfred Douty

hasn't it? Long prior to the Gravell patent? A. Oh, yes.

Mr. Owen: At this point, Your Honor, I wish to read the Interstate Commerce Commission regulations for transportation of explosives and other dangerous articles by freight, including specifications for shipping containers. This is Freight Tariff No. 4 issued January 6, 1941, effective January 7, 1941. On page 94, Section 272(a) it reads as follows:

"Sulfuric acid (oleum, oil of vitriol, etc.) must be packed in specification containers as follows:

"(b) Spec. 15A, 15B, 15C, 16A, or 19A.—Wooden boxes with glass or earthenware inside containers not over 1 gallon each, except that inside containers up to 3 gallons each are authorized when only one is packed in each outside container.

"(c) Spec. 31.—Jugs in tubs. Jugs not over 2 gallons each and only one jug in each tub.

"(d) Spec. 11A or 11B.—Wooden barrels or kegs with glass or earthenware inside containers not over 2 gallons each.

"(e) Spec. 1A or 1C.—Carboys in boxes or kegs; authorized only for acid of not over 100.5 per cent H_2SO_4 .

"(f) Spec. 103A.—Tank cars.

"(g) Spec. 5A.—Metal barrels or drums only for acid of 1.81 specific gravity (65° Baume) or greater strength or when the strength of the acid is 60-65° Baume and the acid has been treated with an inhibitor that renders its corrosive effects on steel no greater than 66° Baume commercial sulfuric acid."

The rest of the section relates to lead lined metal barrels, rubber lined metal barrels or drums, in which we are not particularly interested, and so I will not read it.

Mr. Owen: Now, in view of those specifications, would you say that 66° Baume sulfuric acid would be a safe standard of comparison for determining whether or not it would be safe to store or ship an acid in a steel drum within the meaning of the Gravell patent? A. The person or persons who wrote that specification appeared to think so. I don't

Alfred Douty

necessarily agree with them. I feel that 66° Baume sulfuric acid is very slightly corrosive, indeed, to most steel. A somewhat higher degree of corrosion might be permissible.

Mr. Owen: Now I wish to read the specifications for the shipment of hydrochloric acid. Reading from page 91, Section 263(a) “(1) Hydrochloric (muriatic) acid and hydrochloric acid mixtures must be packed in specification containers as follows:

“(a) (2) Spec. 15A, 15B, 15C, 16A, or 19A.—Wooden boxes with glass or earthenware inside containers not over 1 gallon each, except that inside containers up to 3 gallons each are authorized when only one is packed in each outside container.

“Wooden boxes with glass or earthenware inside containers not over 1 gallon each, except that inside containers up to 3 gallons each are authorized when only one is packed in each outside container.

“(a) (3) Spec. 5D.—Rubber-lined metal barrels or drums. Any such container that shows evidence of damage must be tested, before shipment, for defect in lining in the manner prescribed in spec. 5D.”

And the next one:

(Reading): “(a) (4) Spec. 43A.—Rubber drums.

“(a) (5) Spec. 11A or 11B.—Wooden barrels or kegs with glass or earthenware inside containers not over 2 gallons each.

“(a) (6) Spec. 1A or 1C.—Carboys in boxes or kegs.

“(a) (7) Spec. 10A.—Rubber-lined wooden barrels or kegs.

“(a) (8) Spec. 103B, 108, or 108A.—Tank cars.”

Mr. Owen (reading):

“(b) (1) Hydrochloric acid of not over 20 per cent strength (13.25° Baume) and other corrosive liquids containing not over 20 per cent hydrochloric acid in addition to containers prescribed in sec. 263(a) may be shipped in specification container as follows:

“(b) (2) Spec. 10A.—Asphaltum-lined wooden barrels or kegs.

Alfred Douty

“(c) When hydrochloric acid contains oils or solvents it must not be shipped in containers or tank cars lined with rubber.”

That is the end of the specification for hydrochloric acid.

Mr. Owen: I would like to find what those tank car specifications are, Your Honor. While we are waiting for that section of the regulations, I will ask a few questions.

Q. On these foreign shipments that you refer to, am I correct in understanding that the products were those that you have previously described as Rodine, Murodine, Deoxidine, Deoxylyte? A. I think that includes all the important ones. Not Murodine, we do not ship that in steel.

Q. Oh, you do not ship that on long journeys? A. We do not ship it at all in steel.

Q. But you do ship Rodine, the Deoxylyte, and the Deoxidine, is that right? A. Yes. Sometimes, Mr. Owen, there are special regulations by the shipping companies as to what kind of packages they will take the stuff in, so you have to pack it that way, but I know we have shipped all those products in steel on boats.

Mr. Owen: Well, Your Honor, Mr. Conner gives me this information which he has taken from these freight regulations, and which we will confirm later. We haven't been able to locate the place in them. He says that Tank Specification No. 103B is rubber lined; Tank Specification No. 108 is rubber lined; Tank Specification 108A is asphaltum lined. That is in connection with the shipment of hydrochloric acid.

The Court: By whom?

Mr. Owen: Anybody in Interstate Commerce.

The Court: That is just what you read to me.

Mr. Owen: I read to you in one paragraph, which simply specified these three tanks without telling what they were; specified them by number. I undertook to locate in the regulations the specifications for those particular numbered tanks. I haven't been able to find that but Mr. Conner tells me he has looked it up and that Tank 103B is

Alfred Douty

rubber lined, Tank No. 108 is a rubber lined tank, and Tank No. 108A is asphaltum lined. Those are acceptable for the shipment of hydrochloric acid.

Mr. Owen: I want to ask you again, Mr. Douty—I think I have referred to it once, but I am not entirely clear—if it is not a fact that the products your company manufactures and sells and which you have named, are compounds containing acids and not acids themselves? In other words, instead of shipping acids you are shipping compounds containing acids; that is right, isn't it? A. Well, I don't really recognize any distinction, but for the sake of clarity I will say that we have not, to my knowledge, shipped any material marked such and such kind of acid. We have shipped materials marked Deoxidine or Rodine or what they may be.

The Court: Well, is it inhibited acid or is it just the inhibitor? A. Well, Your Honor, it is both ways.

The Court: I see. All right. You sell both the inhibitor for people to put in acid, and you sell it all ready for use. A. That is right. But in that case we haven't sold it as inhibited acid, Your Honor. We haven't named it inhibited acid or whichever. It had some trade name.

Mr. Owen: You don't sell any acid as such, do you; for instance, you don't advertise that you manufacture and sell phosphoric acid, hydrochloric acid, or any other acid? A. I don't think we advertise it, but we do sell phosphoric acid as such; we have a plant for producing it and we sold that, and what we buy from other sources.

Q. How do you ship that phosphoric acid. A. In all packages, not steel.

Q. In glass, rubber-lined tanks, and so forth? A. Yes, sir.

The Court: Do you sell hydrochloric acid as such too? A. No, Your Honor. We have shipped inhibited hydrochloric acid under the name of Rodine, for cleaning out radiators.

Mr. Owen: Regarding the tank car specifications for the shipment of hydrochloric acid, which were referred to

Alfred Douty

in the quotation I read from the regulations as specifications 103, 108 and 108A for tank cars, I have here a copy of the Interstate Commerce Commission regulations, dated September, 1930, which contains the specifications for those three types of tank cars, and they are rather lengthy. The one for tank car 103 is found beginning page 399; tank car 108 begins on page 432, and 108A begins on page 435, and I find that the first two are rubber-lined cars and the other is an asphalt-lined car.